QUANTITATIVE METHODOLOGY FOR ESTIMATING RESPONSE OF DON RIVER WATER QUALITY CONTROL - SUPPORTING DOCUMENT #1: STRATEGY FOR IMPROVEMENT OF DON RIVER WATER QUALITY

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QUANTITATIVE METHODOLOGY FOR ESTIMATING RESPONSE OF DON RIVER WATER QUALITY CONTROL - SUPPORTING DOCUMENT # 1: STRATEGY FOR IMPROVEMENT OF DON RIVER WATER QUALITY

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Report prepared for:
Steering Committee
Toronto Area Watershed Management Study

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ABSTRACT

As part of the Strategy for Improvement of Don River Water Quality Study, a quantitiative methodology was developed to estimate the effectiveness of control options. The approach was the scenario approach, in which a variety of control options are evaluated and their impact upon water quality considered.

This supporting document presents the methods used, and the response of water quality at four key locations in the Don River system:

i) Upper Don,
ii) Middle Don (at continuency East and West Don),
iii) Lower Don (at Lakeshore Road), and
iv) Mouth of Massey Creek.

A spreadsheet analysis was used to:

- establish instream concentrations for suspended solids, total phosphorus, ammonia, copper, lead and fecal coliforms at the four representative locations; and
- estimate the effectiveness of various mitigative options in reducing concentrations and loadings of the above-noted parameters.

A loading-dilution model, as mandated by the terms of reference of this study, was used to evaluate the effectivess of remediation. All substances were treated as conservative over a suitable time frame except for bacteria which decay in the stream. The methodology was used to evaluate seasonal conditions as well as for dry weather and specific sized rainfall events.

The methodology consisted of the following steps. Present day flows and concentrations of different contamninants from various sources were estimated to give loading to the river for existing conditions. The instream concentrations resulting form these loads were calculated and compared to measured concentrations. Next, the effect of different control measures on the magnitude of source flow or source concentrations were estimated. Then the impact of source control upon riverine concentrations were calculated.

Four typical conditions have been evaluated, these being dry weather conditions and wet conditions for a 5, 10 and 20 mm rainfall event. Dry weather conditions occur a majority of the time (about 70%). On days when precipication does occur, the cumulative daily rainfall volume is less than 5 mm about 50% of the time. Dry weather conditions plus 5 mm of precipitation or less occur about 87% of the time. Precipitation patterns within the Toronto area also show that the likelihood of precipitation on a given day exceeding 10 mm or 20 mm is 7% or 2%, respectively. Thus, of days which have precipitation, rainfall rates of 10 mm/day and 20 mm/day occur 23% and 7% of the time respectively. These four conditions reflect the dominant scenario (dry weather), average wet weather conditions (5 mm) and two less frequent conditions (10 mm, 20 mm). All these statistics for frequency of rainfall are based upon the April 1 to November 30 period for the years 1982 to 1986.

The following remedial measures were considered.

1. North Toronto STP upgrade,
2. North Toronto STP removal,
3. combined sewer overflow removal,
4. urban in-line or off-line ponds,
5. urban and rural wet and dry maintenance practices,
6. urban and rural wet and dry vegetated Best Management Practices,
7. flow reduction through redevelopment,
8. off-line ponds and flow reduction through redevelopment,
9. Items 2 through 7 inclusive.

A considerable amount of effort was put into evaluting mitigative options which would reduce pollutant loads from the storm sewer systems, as the above anlaysis showed that this sources produced a majority of the pollutant loadings:

The results of the calculations are given in Section 6 of this Supporting Document.

FOREWARD

Study Background

In 1981, the Ontario Ministry of the Environment (MOE) began a study of water quality in the Don River, Humber River and Mimico Creek to provide baseline data to guide future studies. The following year, the Toronto Area Watershed Management Strategy Study (TAWMS) was initiated as a comprehensive and co-operative multi-agency undertaking towards the attainment of water quality improvements.

The TAWMS study objectives are:

- To better define water quality conditions with the study area;
- To analyse the cause and effect relationships for problem constituents and areas; and
- To develop cost-effective measures for controlling pollutant loadings to the study area's receiving waters based on watershed needs and users.

Although wholly funded by MOE, TAWMS receives extensive co-operation and support from the Metropolitan Toronto and Region Conservation Authority (MTRCA), Metropolitan Toronto and area municipalities.

The TAWMS study is managed by a Steering Committee which includes representatives of the following:

Ontario Ministry of the Environment
Ontario Ministry of Natural Resources
Metropolitan Toronto & Region Conservation Authority
Environment Canada
Metropolitan Toronto
Borough of East York
City of Etobicoke
City of North York
City of Scarborough
City of Toronto
City of York
Regional Municipality of York
Regional Municipality of Peel
Town of Richmond Hill
Town of Vaughan
Town of Markham

A detailed study of the Humber River was carried out during the period 1982 to 1985. In 1986, the TAWMS Steering Committee released a Management Plan for the Humber River. Recommendations which were outlined in this plan are presently being implemented.

The TAWMS Don River Water Quality Improvement Study was commissioned as an external contract to Paul Theil Associates Limited and Beak Consultants Limited in the spring of 1988. The study's mandate was to summarize water quality problems, relate these problems to sources and to provide a range of improvement actions leading to various levels of control for water quality improvements. Options investigated for water quality improvement range from no further degradation to the full restoration of water quality in the Don River. The findings were presented as alternatives or staged management strategies which will lead to several milestones or levels of water quality improvement.

The improvement strategy incorporates findings from previous investigations of low flow and storm event conditions, snow melt, the status of biological communities and general water quality conditions within the Don River.

Public consultation on a number of strategies for water quality improvement for the Don River, combined with inputs from a range of municipalities and agencies will provide valuable direction for drafting the final Don River Management Plan. Improvement strategies outlined in this report for the Don River and other rivers which drain into the waterfront will be considered in context of the Metro Toronto Remedial Action Plan (RAP), a provincial-federal initiative for protecting water quality in Toronto's waterfront.

Implementation considerations and costs are important components in this option selection/consultant process, since they identify in simple terms what it will take to achieve a range of improvements and benefits or designated uses of the Don River. This consultation process will also recognize the will of municipalities, government agencies, developers and the public to support selected undertakings to protect and enhance water quality in the Don River.

The time span in which water quality improvements are to be derived and the ultimate costs will depend upon the levels of protection and the phasing of controls selected on the basis of public feedback and agency and municipality endorsement. It is recognized that effective improvement actions in the Don River watershed will also require creative solutions and new approaches by the municipalities and government agencies.

In addition to the remedial measures proposed in the strategy, a number of immediate actions are presently underway to address water quality problems by means of regular municipal and conservation authority works and maintenance programs, or through Ministry of the Environment programs such as the Waterfront Water Quality Improvement Program which funds physical work on the watercourses, waterfront or sewers yielding immediate benefits.

This document is Supporting Document 1 for the study. The complete set of study reports are as follows.

1. STRATEGY FOR IMPROVEMENT OF DON RIVER WATER QUALITY: SUMMARY REPORT

2. SUPPORTING DOCUMENT NO. 1: QUANTITATIVE METHODOLOGY FOR ESTIMATING RESPONSE OF DON RIVER TO WATER QUALITY CONTROL

3. SUPPORTING DOCUMENT NO. 2: FRAMEWORK FOR EVALUATING RESPONSE OF AQUATIC TOXICITY AND FISH HABITAT TO WATER QUALITY CONTROL IN THE DON RIVER

4. SUPPORTING DOCUMENT NO. 3 METHODOLOGY FOR EVALUATING IMPACTS OF SPILL REMEDIATION AND OTHER REMEDIAL OPTIONS UPON DON RIVER WATER QUALITY

5. SUPPORTING DOCUMENT NO. 4: PROBLEM DEFINITION: PRESENT STATE OF WATER QUALITY IN THE DON RIVER

6. SUPPORTING DOCUMENT NO. 5: ANALYSIS OF WATER QUALITY DATA FOR THE DON RIVER

Availability of Reports

Copies of the Supporting Documents and the Summary Report for the Strategy for Improvement of Don River Water Quality are available through the:

Public Information Centre
Water Resources Branch
135 St. Clair Avenue W.
Suite 100
Toronto, Ontario
M4V 1P5
(416) 323-4321

DISCLAIMER

THIS STUDY WAS UNDERTAKEN THROUGH A CONTRACT FROM THE METROPOLITAN TORONTO AND REGION CONSERVATION AUTHORITY (MTRCA) AND THE ONTARIO MINISTRY OF THE ENVIRONMENT (OMOE). THE STUDY FINDINGS HAVE BEEN REVIEWED BY THE MTRCA AND OMOE BUT DO NOT NECESSARILY REPRESENT THE POLICY OR POSITION OF EITHER OF THESE AGENCIES.

THIS REPORT HAS BEEN REVIEWED BY THE STEERING COMMITTEE AND APPROVED FOR PUBLICATION. APPROVAL DOES NOT NECESSARILY SIGNIFY THAT THE CONTENTS REFLECT THE POSITION AND/OR POLICIES OF INDIVIDUAL AGENCIES.

TABLE OF CONTENTS

		Page
1.0	INTRODUCTION	1.1
2.0	STUDY AREA	2.1
3.0	METHODOLOGY	3.1
	3.1 Flow Quantity	3.2
	3.1.1 Precipitation and Flow Data	3.3
	3.1.2 Calibration of Rainfall-Runoff Rate Relationships for Separated Storm Sewers	3.4
	3.1.3 Calibration of Volume of Runoff	3.5
	3.1.4 Discharge Volumes	3.7
	3.2 Flow Quality	3.8
	3.2.1 Source Concentrations	3.8
	3.2.2 Calibration of Loadings	3.9
4.0	EXISTING SOURCE LOADINGS AND INSTREAM CONCENTRATIONS	4.1
	4.1 Existing Source Loadings	4.1
	4.2 Existing Instream Concentrations	4.1
5.0	CONTROL OPTIONS	5.1
	5.1 Control Option Scenarios Considered	5.1
	5.2 Control Option Effectiveness	5.3
6.0	SUMMARY	6.1
7.0	REFERENCES	7.1

APPENDIX 1: Summary of Water Quality Data for Don River Outfalls and Tributaries - Supporting Document No. 1

1.0 INTRODUCTION

As part of the Strategy For Improvement of Don River Water Quality study, a quantitative methodology was required to estimate the effectiveness of control options. This document presents the methodology used and results obtained for estimating source loadings under existing conditions and with the implementation of control options.

A simplified analysis was used to:

- calculate instream concentrations for six water quality parameters at the four representative locations; and
- estimate the effectiveness of various mitigative options in reducing concentrations and loadings of the above-noted parameters.

A loading-dilution model using spreadsheet techniques was mandated by the terms of reference of this study to evaluate effectiveness of remediation. The model estimates loadings from all sources, their reduction due to remedial measures, and the concentration as the net loading divided by the stream flow rate. All substances are treated as conservative over a suitable time frame except for bacteria which decay in the stream. The methodology was used to evalute seasonal conditions as well as dry weather and specific sized rainfall events. Since the overall study objective is to establish strategies and plans, a highly detailed analysis was not required, as might be dealt with in detailed design oriented type studies for source control, or detailed stream analysis to forecast absolute magnitudes of compliance with water quality objectives.

The methodology used in this study consists of the following steps. Present day flows and concentrations of different contaminants from various sources were estimated to give loading to the river for existing conditions. The instream concentrations resulting from these loads were calculated and compared to measured concentrations. Next, the effect of different control measures on the magnitude of source flow or source concentrations were estimated. Then the impact of source control upon riverine concentrations were calculated.

Both flow and loading components of the model were calibrated to observed flows and concentrations. This gives confidence in its calculations on a seasonal basis, but it is less precise for specific events due to source loading conditions and instream loadings.

The control options considered in this document are only those which were dealt with in a quantitative manner. Several other management options were dealt with in a qualitative manner, such as fisheries enhancement and spills control. These options are presented in Supporting Document 2 (fisheries enhancement; toxicity reduction) and Supporting Document 3 (spills control and other options) respectively.

Control option effectiveness in this component of the Don River study was evaluated using the scenario approach. The scenario approach poses a variety of control options for evaluation and then considers their impact upon water quality. The scenarios are formulated by considering each control option individually and in combination.

Several sources and source conditions of discharge were analyzed. These sources and conditions were as follows:

1. rural dry weather
2. rural wet weather
3. combined sewer overflow (CSO)
4. urban dry weather
5. urban wet weather
6. North Toronto Sewage Treatment Plant (STP)

Although the STP and CSO sources are urban in origin, they were separately quantified in this study. The urban dry and wet sources refers specifically to discharges from storm sewer outfalls during the two different weather conditions.

Water quality parameters considered in this quantitative assessment were suspended solids, total phosphorus, ammonia, copper, lead and fecal coliforms. Other water quality parameters such as organics were examined qualitatively (e.g., see Section 3.3.2 in summary report).

2.0 STUDY AREA

The study area encompasses the entire Don River watershed from the headwaters in the Oak Ridges moraine to Lake Ontario at the Keating Channel, approximately 340 square kilometres, see Figure 1. There are ten municipalities, two of which are regional municipalities within the Don River watershed. The local municipalities are:

Borough of East York (Metro);
Town of Markham (York);
City of North York (Metro);
Town of Richmond Hill (York);
City of Scarborough (Metro);
City of Toronto (Metro);
Town of Vaughan (York);
City of York (Metro);

The regional municipalities are:

Metropolitan Toronto; and Region of York.

For this study the Don River watershed was divided into eleven subcatchments. These catchments were based on smaller sewage catchment areas established in a previous watershed mapping study (Anderson Associates 1984). These catchments were further compiled into four study reaches and adjusted to reflect 1988 development conditions. Listed below are the four reaches and the associated catchment areas.

Reach	Sub-Catchments
Upper Don	1,5
Middle Don	2,3,4,6,7,8
Lower Don	10,11
Massey Creek	9

In Table 1 land use, sewerage and percent impervious data are presented for each of the eleven sub catchments. This data provides information on the extent of development within the Don River Basin and essential information required in estimating pollutant source loadings. Under present day conditions approximately 72 percent of the watershed is developed. Open land, including parks, comprises 33 percent of the

DON RIVER WATERSHED
FIGURE 1

----WATERSHED BOUNDARY

TABLE 1

DON RIVER WATERSHED CHARACTERISTICS

Catchment Area Number	Storm Sewer Drainage Area (ha)	Combined Sewer Drainage Area (ha)	Total Area (ha)	Industrial Area (ha)	Open Area (ha)	Residential Area (ha)	Commercial Area (ha)	Other	Percent Impervious (percent)
1	3,300	0	3,300	600	2,500	100	30	30	16
2	7,700	0	7,700	2,100	2,400	3,000	100	100	35
3	1,500	0	1,500	70	100	1,200	100	20	46
4	100	100	200	50	20	70	10	0	45
5	3,500	0	3,500	250	2,300	900	60	0	20
6	1,200	0	1,200	100	400	700	20	0	35
7	3,200	0	3,200	400	1,400	1,300	100	30	30
8	5,500	0	5,500	700	1,000	3,000	200	200	42
9	2,400	600	3,000	600	400	1,500	100	20	43
10	1,100	100	1,200	80	300	600	100	40	40
11	3,000	500	3,500	300	400	2,200	300	30	49
TOTAL	32,500	1,300	33,800	5,250	11,220	14,570	1,120	470	

watershed; 15 percent is industrial land; 43 percent is residential and the remaining 9 percent is commercial and highway land. Some of the open space is currently under and/or planned development.

Sixty-three (63) percent of the entire watershed is serviced by storm sewer drainage systems and 4 percent is serviced by combined sewer systems. The combined sewer systems are located within the Cities of Scarborough and Toronto and the Borough of East York. Most of the remaining combined sewer areas are under sewer separation programs. These programs, however, only partially separate the combined sewer system, as only road runoff is removed. Where roofs and foundation drains are connected to sanitary sewers of the separated sewer system, they still augment sanitary sewerage with storm water flows.

The percent imperviousness presented in Table 1 is the area weighted mean based on the various land uses within each sub catchment. The area weighted average imperviousness for the entire watershed is 35 percent.

3.0 METHODOLOGY

The approach used was designed to estimate daily loadings for each parameter from the various sources and reaches to determine resulting riverine concentrations. It was also designed to examine the frequency of occurrence of the various daily flow conditions so that remedial strategies could focus on events which occurred for significant portions of the year.

The methodology used was based upon a loading-dilution model. In this approach, the concentration in the river is calculated as the loading to the river to that point divided by flow rate at the point of concern. This approach was mandated by the terms of reference for this study which stated "the study will not incorporate detailed stream modelling of the watershed".

The resultant riverine concentrations calculated by this methodology, hence, assume that there are no net settling reactions within the river itself over a suitably long time scale. Settling reactions, do however, occur in stormwater management ponds and reservoirs. This assumption is reasonable for four of the parameters considered in this study: suspended solids, total phosphorus, copper and lead. It is suspect for ammonia and inappropriate for bacteria.

Nitrogen transformations involving internal sources of ammonia occur in the river. This requires that the evaluation of ammonia be treated conditionally in the watershed above the North Toronto STP discharge. Below the STP discharge, the loading-dilution gives reasonable results for ammonia, particularly due to the higher levels of ammonia compared to upstream reaches. For bacteria, a decay model was imposed on the loading-dilution model to account for die-off and removal processes. An order of magnitude die-off for a hydraulic residence time of 1-2 days was used to establish the decay coefficient.

This modelling approach has one major limitation. It does not allow separation of wet weather effects from dry weather effects in an easy fashion. In-stream concentrations particularly during wet weather events, represent a combination of instantaneous loadings from land-based sources during the event, and instream loadings. The instream loadings occur due to erosion of bottom materials previously deposited during dry

weather periods. Concentrations during dry weather result from the recession of hydrographs after rainfall events and other instream removal processes such as settling.

Irrespective, dry weather and wet weather conditions are separated below to allow insights into the response of the system due to selective controls (dry weather; dry weather plus a certain fraction of wet weather events). The calculated responses can be used for evaluation of effectiveness in a relative sense.

Relatively basic mathematical equations were used to estimate discharge volumes from urban and rural runoff and CSO's for each of the eleven sub catchments during wet weather. Dry weather discharge volumes from urban, rural and STP sources were directly applied from previous studies and calibrated to instream data. Loadings were calculated by multiplying source discharge volumes by source concentrations for each parameter. Loadings from each catchment were added for the various reaches and a mass balance was carried out to establish riverine concentrations.

Both the source volumes and resulting instream concentrations were calibrated to observed data. The objective of calibration is to establish values for flow and concentration from the various land based sources which would produce results consistent with measured records. The calibration procedure ensured that reasonable results were attained for the methodology used.

For control option analyses, the source volumes and concentrations were adjusted by applying an appropriate removal factor to the discharge volume or concentration reduction factor.

Management of the data and calculations was carried out using computer spread sheet models. The spread sheets were designed such that by varying input parameters like rainfall depths and concentration reduction factors, loadings for each catchment and for each reach would be recalculated and summarized in tabular form.

3.1 Flow Quantity

One of the two main components in establishing pollutant source loadings is the volume of runoff from different sources and the associated river flow. The runoff volume influences the mass of a particular pollutant discharged from a given source. Generally

the runoff volume flow is not a significant factor in the estimation of pollutant concentrations for separated storm sewers. The runoff rate and volume is a function of rainfall factors, sewer hydraulic factors, and control techniques. Although hydraulic elements are designed for specific flow rates the basic principal for most flow control options is to reduce the volume of discharge. Precipitation volume and frequency of occurrence formed the basis for estimating daily loading from all sources except for the STP. A description of the precipitation and flow data used in this study are now presented.

3.1.1 Precipitation Characteristics

In order to estimate existing conditions and test the effectiveness of control options, typical hydrologic conditions were analysed. One year (1984; see below) was selected for analysis in which conditions were not more dry or wet then those normally experienced for the Don River watershed. The effectiveness of control was further simplified to analyze a set of conditions over the complete range of hydrological conditions, rather than analysing all possible conditions. The change in loadings due to water quality control were estimated for storm events which produced rainfall depths of 5, 10, 15, 20, 30 and 60 mm.

It was assumed that if precipitation occurred on a given day, that day was classified as a wet day. Storm events less than 5 mm were considered as wet days even though the effects of these minor events are borderline conditions between wet and dry days.

Data are presented on the occurrence of various size storm events in Table 2 and Figure 2. These data were derived from Atmospheric Environment Services (AES) daily precipitation records from April to November for years 1982 to 1986. The data show that dry weather flow conditions occur for 70 percent of the time and that small wet events (less than 5 mm) plus dry conditions occur 87 percent of the time. Days, with greater than 20 mm of rainfall, occur only 2 percent of the time.

Not considering source concentrations, this information indicates that a significant degree of control could be attained by controlling just dry and wet storm events of up to 5 mm.

TABLE 2

DISTRIBUTION OF DAILY
PRECIPITATION EVENTS

Amount of Rain/Day (mm)	* Number of Days With Rain	Percent Occurance	Percent of Days Exceeding
(dry)0	168	69	31
2	25	10	21
5	19	8	13
10	13	5	8
15	9	4	4
20	5	2	2
30	2	1	1
60+	2	1	0

* Arithmetic mean for years 1982 to 1986, from April 1 to November 30.

DISTRIBUTION OF DAILY PRECIPITATION
IN THE DON RIVER WATERSHED

FIGURE 2

3.1.2 Calibration of Rainfall-Runoff Rate Relationships for Separated Storm Sewers

For calibration purposes a typical hydrological year was used. The objective of calibrating to a typical year of rainfall was to asses daily discharge constants and relationships for daily conditions to represent typical seasonal conditions. The constraints in selecting a single year were the water quality and watershed characteristics data available for this study. The best water quality data for calibration purposes were available for the years 1982 to 1986 inclusive.

Both precipitation and Don River flow records were reviewed for the period of 1982 to 1986. Precipitation data from 8 Canadian AES stations located within the Don River watershed (see Figure 3) were assessed. Flow records were obtained from Water Survey of Canada for two stations: Todmorden and York Mills, see Figure 1. The Todmorden station is located just down stream of the North Toronto STP in the lower reach and the York Mills station is located on the East Don River tributary.

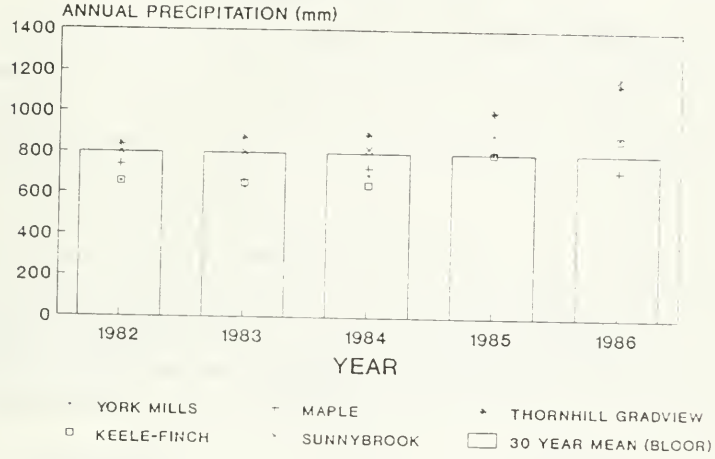
For each year, monthly precipitation depth and measured flow volumes were plotted, and compared to long term averages. These plots are shown in Figures 3 and 4. Review of both figures indicate that 1984 the quantity and distribution conditions are most comparable to the long term mean. Hence, 1984 was selected as the typical hydrological year.

The AES Toronto Sunnybrook station was selected to represent the watershed. Although one rain gauging station can never represent rainfall conditions for the entire watershed the methodology limited the analysis to a single station. The assumption is that for a given storm event the intensity and distribution of the storm event is uniform throughout the watershed. This assumption gives conservative results by over estimating the total rainfall loading to the Don River for any one event.

The 1984 precipitation records, typical Don River watershed characteristics and a simulation model were used to establish volumetric runoff coefficients for the different size of events. This analysis was carried out using a continuous modelling program. Continuous modelling allowed modelling of variable size and distribution of storm events throughout the year for different impervious and soils characteristics. The US EPA SWMM program (Computational Hydraulics) was used for this analysis. The model was

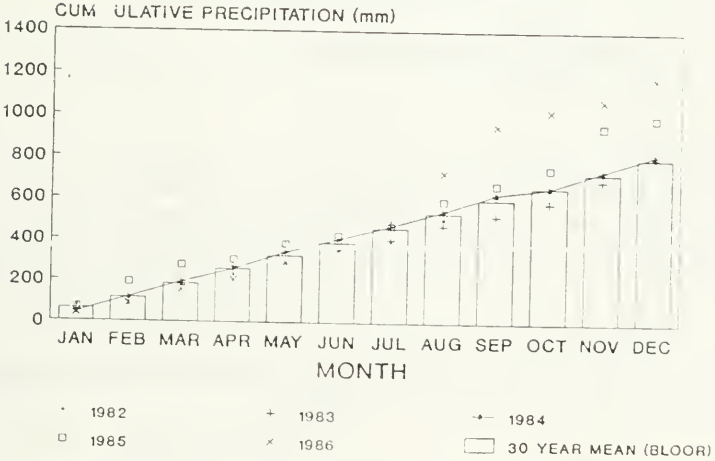
RAIN GAUGE COMPARISON
1982-1986 ANNUAL PRECIPIATTION

FIGURE 3



30 YEAR MEAN AT BLOOR STATION 1951-1980

TORONTO SUNNYBROOK RAIN STATION
1962-1986 MONTHLY PRECIPITATION

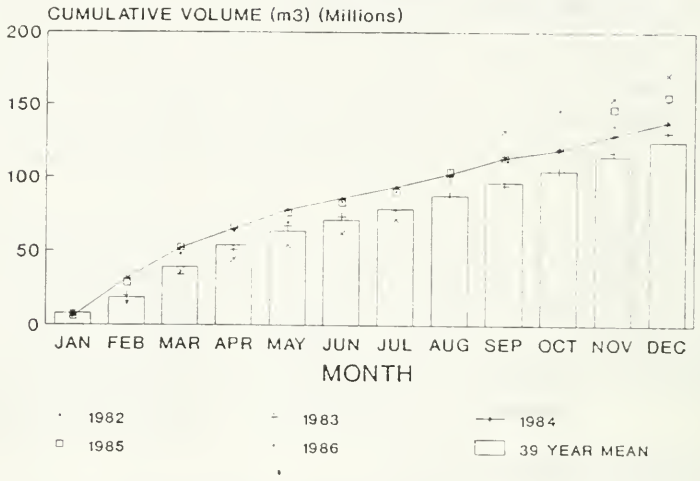


30 YEAR MEAN AT BLOOR STATION 1951-1980

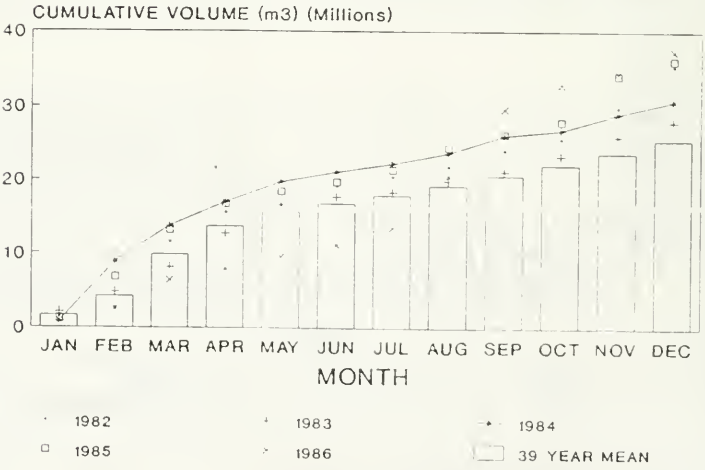
PRECIPITATION DATA SELECTION

FIGURE 4

DON RIVER TODMORDEN STATION
1982-1986 FLOW



DON RIVER YORK MILLS STATION
1982-1986 FLOW



INSTREAM FLOW DATA SELECTION

applied to a generic one hectare catchment and the results applied to different land use characteristics of the Don River.

The primary factors controlling runoff volume were established by a sensitivity analysis. The factors, in decreasing order of sensitivity are drainage area, percent imperviousness and soil type. The parameter having the greatest variability and the greatest sensitivity in this study was the degree of imperviousness. The degree of imperviousness varies from 5 percent for open space land to 90 percent for highly developed industrial areas. The study area weighted mean percent imperviousness is 35.

In Figure 5 a plot of continuous simulation modelling results showing runoff depth versus precipitation depth is presented for three degrees of imperviousness. From these plots a range of volumetric runoff coefficients were determined. Except for the initial runoff from small events (less than 5mm) the relationship of runoff to precipitation is relatively linear. The slope of these lines provide the following volumetric runoff coefficients.

percent imperviousness	volumetric runoff coefficient
30	0.26
40	0.33
70	0.58

For smaller events the volumetric coefficients converge, therefore, a single coefficient of 0.1 was used. For the larger events the volumetric runoff coefficients were plotted with the associated percent imperviousness. This relationship is presented in Figure 5. The relationship was fitted with a linear regression. The resultant equation between runoff volume and the percent imperviousness, is:

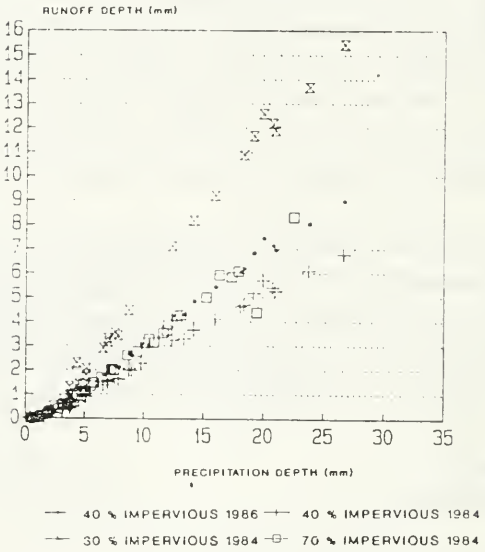
Runoff Coefficient = 0.00811 x % impervious + 0.115

3.1.3 Calibration of Volume of Runoff

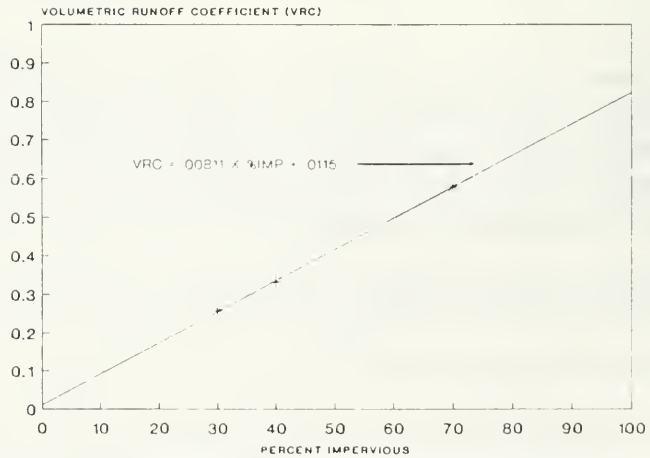
The volumes of runoff resulting from the above relationship, and estimates of runoff from other sources (CSO's, STP's) were checked with observed flow data. The procedure

FIGURE 5

RUNOFF DEPTH VS. PRECIPITATION DEPTH
DATA FROM CONTINUOUS SIMULATION



RUNOFF VOULUME VS PERCENT IMPERVIOUS



SOURCE VOLUME RUNOFF PARAMETERS

involved a comparison of cumulative daily volume discharge from all sources within each sub catchment to the cumulative volume observed instream in 1984. This procedure was carried out for each of the stream gauging stations. The York Mills station provided calibration for urban and rural, dry and wet sources. The Todmorden station allowed for calibration of most of the watershed including flows from the STP and most of the CSO's.

The North Toronto STP operates at a controlled uniform rate of 394 l/s or 7.5 MGD (Gore and Storrie, 1987), therefore, no calibration for this source volume was carried out.

The CSO volumes of runoff were initially estimated from a statistical methodology developed for the U.S. EPA (Driscoll, 1986b). From this approach approximately 75 percent of runoff volume from combined sewer areas would end up as CSO for a mean storm event of 6.6 mm (Proctor and Redfern 1987).

These initial estimates were checked with the results of pollution control studies carried out for the City of Scarborough and the Borough of East York (Proctor and Redfern and Gore and Storrie respectively). In each of these studies estimates of CSO volumes and frequencies were determined through more detailed modelling techniques. The results from these studies were used to adjust the initial estimates of the quantities of CSO volumes leaving the appropriate sub catchments. Both the frequency of occurrence and the volume of CSO were calibrated. The volumes were adjusted by changing the percent of runoff to overflow and the frequency was calibrated by limiting the size of events which would cause overflow.

No CSO volume estimates are available for the City of Toronto. Accordingly, the Driscoll derived estimates were retained for use in this study. The calibration of the source volume from CSO's is very insensitive to the cumulative mass calibration carried out. This is caused by the volume of CSO discharges being relatively low compared to other wet weather sources. The greatest impact of CSO loadings are the much higher source concentration of pollutants, particulary fecal coliforms compared to other pollutant sources.

Dry and wet weather runoff volumes from separated storm sewers were initially set equal to measured dry weather flows from the Don River Outfall Survey (Canviro) and from the precipitation runoff relationship established earlier.

Initial calibration runs showed that the daily cumulative volumes for 1984 higher at the end of the year than those observed. This was primarily due to an over estimation of dry weather flows and winter snow accumulation/melt conditions. Precipitation during winter months was assumed to accumulate during winter and to melt in spring. Carryover snowpack which melted in the spring introduced excess volumes and were not totally recovered in the accumulation of snowpack later in the year. Due to the approach used, an analysis of snowmelt conditions was beyond the scope of the modelling techniques. Accordingly, this study concentrated upon calibrating the flow volume model for summer (May to November) conditions.

The initial dry weather flow calibration was high. Reasons for the higher volumes are attributed to the time of year that the dry weather flow study of Canviro (1986) was carried out, September to November 1984. This time of year generally has higher ground water levels and base flows. Extrapolation of estimates from the autumn to the entire summer season could produce excessive cumulative volumes. To obtain a better estimate of the Don River base flow conditions information was obtained from historical flow records and analysis of base flows in Ontario Streams (NHRI 1984). This data supported the use of lower dry weather volumes than suggested by the Canviro study.

Having a better dry weather estimate allowed for calibration of CSO and wet weather volumes such that the daily cumulative volume reasonably comparable to observed data. The final calibration plots are shown in Figure 6.

3.1.4 Discharge Volumes

Once reasonable discharge parameters and source volumes were derived through calibration the daily quantities of discharge were determined for dry conditions and storm events of 5, 10, 15 and 20 mm in size. These volumes of discharge are presented in Table 3.

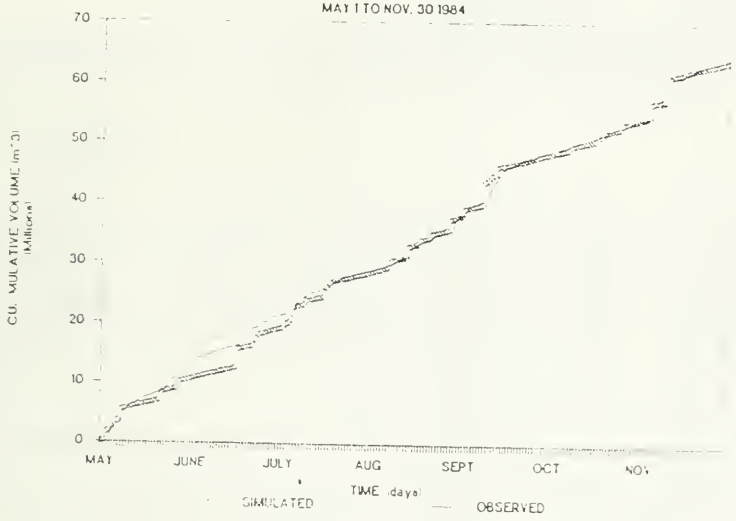
From the data presented in Table 3 the following points are highlighted:

1. The North Toronto STP accounts for 31 percent of the total daily dry weather flow volume.

FIGURE 6

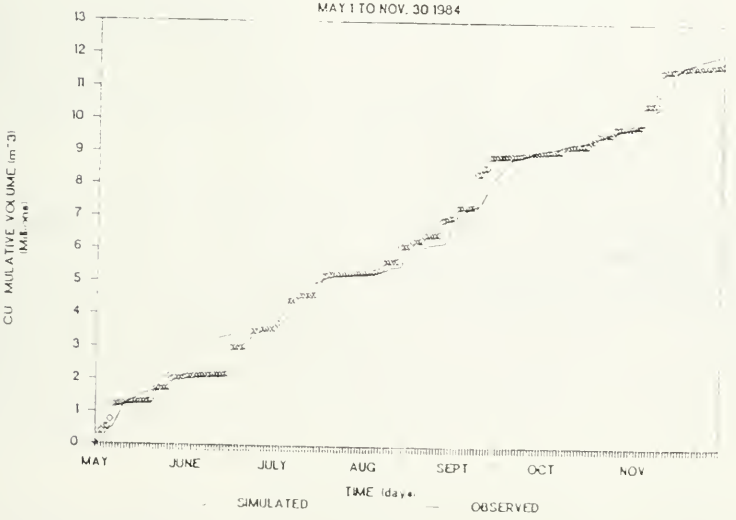
TODMORDEN STATION VOLUME CALIBRATION

MAY 1 TO NOV. 30 1984



YORKMILLS STATION VOLUME CALIBRATION

MAY 1 TO NOV. 30 1984



SOURCE VOLUME CALIBRATION

TABLE 3

VOLUME OF SOURCE DISCHARGES
BY DAILY CONDITIONS

BY CATCHMENT	NORTH TORONTO STP	URBAN & RURAL DRY	URBAN AND RURAL WET				CSO			
			0-5 mm	5-10 mm	10-15 mm	15-20 mm	0-5 mm	5-10 mm	10-15 mm	15-20 mm
NUMBER OF DAILY OCCURANCES/SEASON	244	168	44	13	9	5	44	13	9	5
% OCCURANCE	100	69	18	5	4	2	18	5	4	2
1	-	8	23	46	70	92				
2	-	18	112	224	336	449				
3	-	4	29	58	87	116				
4	-	1	3	5	8	10	0	3	4	6
5	-	8	20	60	59	121				
6	-	3	18	37	55	73				
7	-	4	34	80	120	161				
8	-	13	97	193	290	387				
9	-	7	44	87	131	174	0	5	10	14
10	-	3	18	37	55	73	0	2	4	5
11	34	8	60	121	181	241	0	13	21	29
BY REACH										
UPPER DON	0	16	43	106	129	213	0	0	0	0
MIDDLE DON	0	43	293	597	896	1196	0	3	4	6
LOWER DON	34	11	78	159	236	314	0	15	25	34
DISSEY CREEK	0	7	44	87	131	174	0	5	10	14
TOTAL SEASONAL VOLUME	34	77	458	948	1392	1897	0	23	39	54
	8296	12936	20152	12324	12528	9485	0	299	351	270

Notes: All units in 1000 cubic metres
SEASONAL VOLUME = # OF OCCURANCES/SEASON * VOLUME/OCCURANCE
VOLUMES FOR EACH RAINFALL GROUP ARE CONSERVATIVE

2. The relative total seasonal volumes of discharge from highest to lowest are storm runoff at 71 percent, dry weather flow at 17 percent, North Toronto STP at 11 percent and CSO at 1 percent.

3. Approximately 60 percent of the storm runoff volume occurs for events less than 10 mm in size which represent 80 percent of the rain days.

3.2 Flow Quality

The second major component in establishing source loadings are source pollutant concentrations. Concentration indicates the quantity of a given pollutant in a per unit of volume of runoff. For most parameters this value is in units of milligrams per litre (mg/l). Fecal coliforms are presented in bacterial density unit counts per 100 ml of sample.

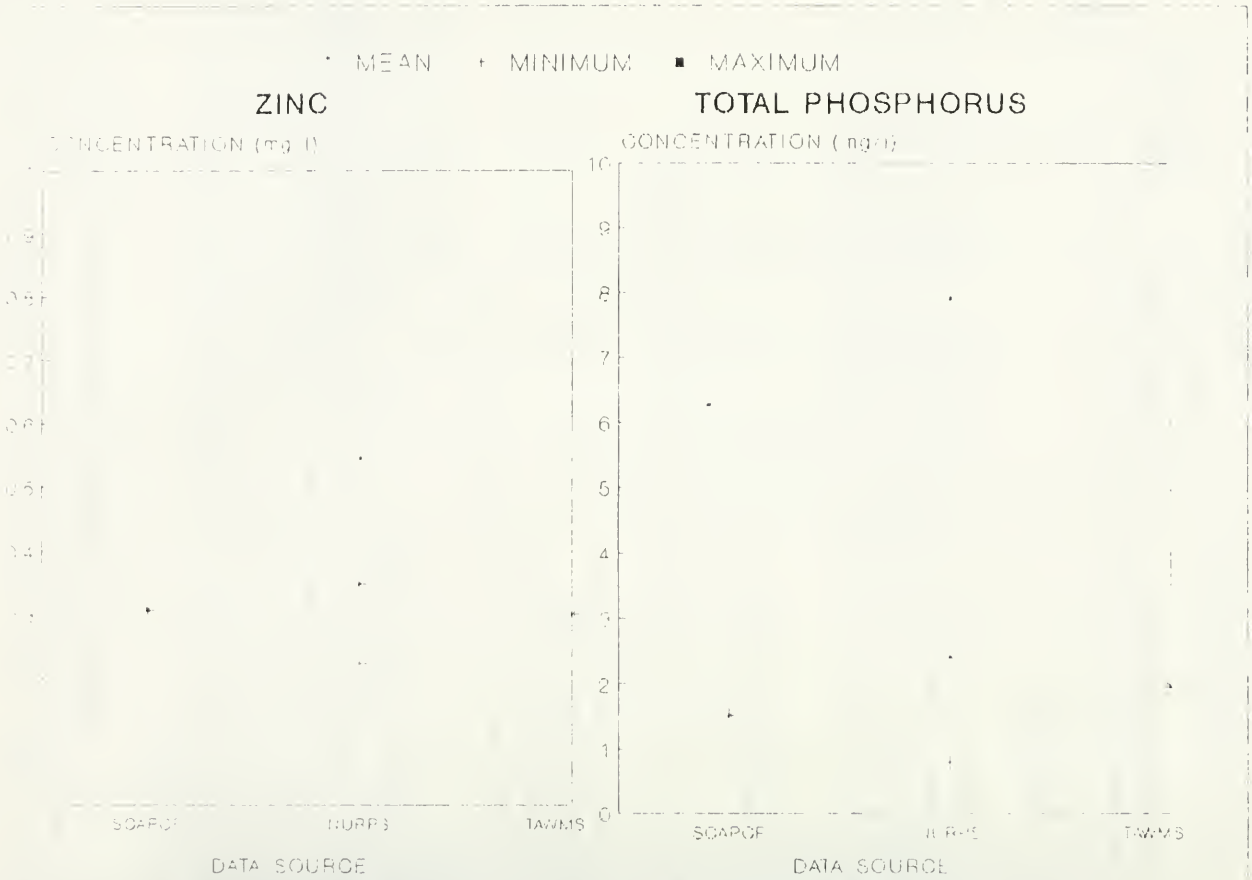
3.2.1 Source Concentrations

Various sources of water quality data were used in this study including:

1. North Toronto STP Records
2. TAWMS Don River Studies
3. TAWMS Humber River Studies
4. US EPA NURP (National Urban Runoff Program) Study

Quality data used to the greatest extent was from the NURP data base. This data base was considered more sound compared to other data sources due to its size. For example 164 CSO events were sampled at 18 sites in 7 cities. CSO data from the NURP study were compared to Ontario data (Theil 1988) and found to show relatively little difference between the event mean concentrations. For most parameters the mean for data in southern Ontario (Toronto and St. Catherines) falls within the range of observed data in the NURP data base. In Figure 7 an example of this comparison is shown for zinc and total phosphorus.

These similarities support the conclusion derived by the NURP data base which found the event mean concentration (EMC) of urban runoff to have little correlation with land use (Driscoll, 1986b). That is, land use such as residential, mixed commercial and



RELATIVE WATER QUALITY CONCENTRATIONS
FOR ZINC AND TOTAL PHOSPHORUS
FROM THREE DATA SOURCES

FIGURE 7

commercial does not show substantial differences in mean water quality, particularly in comparison to the range of water quality observed. Furthermore, the distribution of mean concentrations is independent of the volume of flow of these events. This means for a range of storm events, that the event mean concentration has no functional relationship to the flow volume. Loadings are, however, more predictable by flow volume and not on concentration, since there is a general relationship between rainfall volume and runoff volume, but not between rainfall volume and runoff quality.

The pollutant concentration data used for the various pollutant sources are listed in Table 4.

3.2.2 Calibration of Loadings

Although instream water quality data for the Don River was available at several locations within the watershed only a limited number of parameters and locations were considered in this study. For purposes of calibration both flow weighted and time weighted average instream data were used. Instream concentrations were calculated from the various sources to obtain both time weighted and flow weighted concentrations. As noted above, the modelling of instream processes were not carried out except for bacterial densities.

Flow-weighted concentrations reflect total annual loading; they are calculated as the total annual load divided by total annual flow. They combine loadings during all wet weather events and dry weather events. Time-weighted concentrations reflect the average annual concentration if one monitoring spot in the river were sampled every day of the year. Flow-weighted concentrations provide an indication of the impact on Lake Ontario of the waters discharged from the Don. Time-weighted concentrations provide a measure of risk to aquatic biota assuming a linear concentration-exposure risk model.

The flow-weighted and time-weighted concentrations used for the calibration are given in Table 5a. Loadings passing the Todmorden monitoring station were calculated from the enhanced monitoring program (BEAK, 1988) for only two of the parameters considered in this study (suspended solids, total phosphorus). These values were used to establish calibration data for the "flow-weighted" concentrations.

TABLE 4

SOURCE CONCENTRATIONS (mg/L)

Parameter	Urban DWP	Rural DWF	STP	CSO	Urban Runoff	Rural Runoff
SS	5	5	8.3	184	250	250
TP	0.3	0.15	0.8	2.4	0.33	0.06
Ammonia	0.01	0.01	5	1.9	0.3	0.2
Copper	0.02	0.001	0.04	0.102	0.033	0.004
Lead	0.002	0.002	0.04	0.346	0.144	0.003
FC*	3000	12	3.4	500000	10000	500
FC**	33000	120	3.4	10^6	20000	1000

Notes: - These are the values after Calibration, not before.

FC* In units of counts/100 ml.

FC** Source concentration before accounting for decay.

TABLE 5a

OBSEVED FLOW-WEIGHTED AND TIME-WEIGHTED CONCENTRATIONS

Parameter	Flow-Weighted	Time-Weighted @Todmorden	Time-Weighted @Don River Mouth
Suspended Solids	215	16-20	15.00
Total Phosphorous	0.4	0.26-0.34	0.19
Ammonia	---	0.87	1.46
Copper	---	0.009-0.011	0.010
Lead	---	0.01-0.011	0.007
Fecal Coliform	---	1000	1760

Table 5b
Model Calibration Results

Parameter	Flow-Weighted	Time-Weighted
Suspended Solids	213	15
Total Phosphorous	0.42	0.07
Ammonia	0.67	0.19
Copper	0.029	0.004
Lead	0.09	0.007
Fecal Coliform	39000	3000

There are a variety of monitoring data available in the Provincial Water Quality Monitoring Network (PWQMN) data base. These data are obtained on a fairly regular basis and hence are assumed to provide reasonable estimates of time-weighted concentrations. Median concentrations from the summary analysis of Bodo (1987) for Todmorden and the Don River mouth station are used as estimates of time-weighted concentrations.

The formula used for calculating instream concentrations for any day is:

$$C_{RIVER} = \frac{SSS(C_{SOURCE} * (1-R_3)) Q_{SOURCE})}{SSS\, Q_{SOURCE}}$$

Here: SSS is the sum over all sources;
C_{SOURCE} is the concentration in any source i;
Q_{SOURCE} is the flow rate (or daily flow volume) for each source i;
C_{RIVER} is the riverine concentration.
R_3 is the amount of removal which occurs due to instream processes.

As noted above, the modelling of instream processes was carried out only for bacteria. For bacteria in the lower Don, R_3 was assigned a value of 0.9 for example, when bacteria originating from upstream sources are considered. These processes were incorporated into the spreadsheet by transforming C_{SOURCE} $(1-R_3)$ into an equivalent value for concentration.

The loading-dilution spread sheet model was collibrated to observed instream data by adjusting source concentration data. The results of the calibration process are presented in Table 5b. The results show reasonable for suspended solids and total phosphorus for flow weighted values and for time-weighted values for suspended solids, lead and fecal Coliforms. A poorer time weighed calibration was obtained for total phosphorus, ammonia and copper. For some parameters such as fecal coliforms the calibration required a considerable adjustment of source concentrations, after accounting for decay.

4.0 EXISTING SOURCE LOADINGS AND INSTREAM CONCENTRATIONS

Source loadings were calculated for each catchment and for each parameter for the range of precipitation conditions (dry, 5, 10 and 20 mm events). Loadings were obtained by multiplying the source volume for a given condition by the source mean concentration. The source loadings were compiled into the four basic reaches by combining the loadings from the appropriate sub catchments.

The existing source loadings for each of the four reaches are given in Tables 6 to 12 for each parameter and for the various precipitation conditions. Data presented in the tables are also presented as pie charts in Figures 8 to 23. Factors used to calculate the effect of control options are given in Table 13.

4.1 Existing Source Loadings

Review of these data for present conditions shows the following:

1. During dry weather conditions urban and rural discharges are the primary loading sources upstream of the STP. The primary source of copper, lead and total phosphorus in the lower reach is the North Toronto, STP.

2. Urban runoff is the predominant wet weather loading source for all parameters tested except for fecal coliform. In the lower reach and in particular Massey Creek, the largest contribution of fecal coliform loadings is from CSO's.

3. Larger fecal coliform loadings from CSO's are due to the higher concentrations in CSO by two orders of magnitude. Urban runoff sources dominate due to relatively high source volume discharges.

4.2 Existing Instream Concentrations

Instream concentrations generated through spread sheet modelling are presented in Table 14 to 17. In general the results of the analysis show that:

TABLE 6

EXISTING SUSPENDED SOLIDS LOADINGS
BY SOURCE REACH AND RAINFALL AMOUNT

	Rainfall Amount	DWF Urban	DWF Rural	SOURCE STP	SOURCE CSO	Urban Runoff	Rural Runoff	TOTAL
Upper Don R.	0	23	57	0	0	0	0	80
Middle Don R.		217	73	0	0	0	0	290
Lower Don R.		308	73	283	0	0	0	664
Massey Creek		36	0	0	0	0	0	36
Upper Don R.	5	0	0	0	0	7,796	5,526	13,403
Middle Don R.		0	0	0	0	80,890	7,143	88,323
Lower Don R.		0	0	283	0	111,442	7,143	119,250
Massey Creek		0	0	0	0	10,884	0	10,920
Upper Don R.	10	0	0	0	0	15,592	11,053	26,725
Middle Don R.		0	0	0	486	161,780	14,287	176,843
Lower Don R.		0	0	283	4,244	222,884	14,287	242,078
Massey Creek		0	0	0	978	21,767	0	22,781
Upper Don R.	20	0	0	0	0	31,184	22,106	53,370
Middle Don R.		0	0	0	1,094	323,560	28,573	353,517
Lower Don R.		0	0	283	9,955	445,767	28,573	484,960
Massey Creek		0	0	0	2,607	43,535	0	46,178

TABLE 7

EXISTING TOTAL PHOSPHORUS LOADINGS
BY SOURCE REACH AND RAINFALL AMOUNT

	Rainfall Amount	DWF Urban	DWF Rural	SOURCE STP	CSO	Urban Runoff	Rural Runoff	TOTAL
Upper Don R.	0	1	2	0	0	0	0	3
Middle Don R.		13	2	0	0	0	0	15
Lower Don R.		19	2	27	0	0	0	48
Massey Creek		2	0	0	0	0	0	2
Upper Don R.	5	0	0	0	0	10	1	15
Middle Don R.		0	0	0	0	107	2	124
Lower Don R.		0	0	27	0	147	2	197
Massey Creek		0	0	0	0	14	0	17
Upper Don R.	10	0	0	0	0	21	3	26
Middle Don R.		0	0	0	6	214	3	239
Lower Don R.		0	0	27	55	294	3	401
Massey Creek		0	0	0	13	29	0	44
Upper Don R.	20	0	0	0	0	41	5	50
Middle Don R.		0	0	0	14	427	7	463
Lower Don R.		0	0	27	130	588	7	773
Massey Creek		0	0	0	34	57	0	94

TABLE 8

EXISTING AMMONIA LOADINGS
BY SOURCE REACH AND RAINFALL AMOUNT

	Rainfall Amount	Ammonia DWF Urban	DWF Rural	SOURCE STP	CSO	Urban Runoff	Rural Runoff	TOTAL
Upper Don R.	0	0.0	0.1	0.0	0.0	0.0	0.0	0.2
Middle Don R.		0.4	0.1	0.0	0.0	0.0	0.0	0.6
Lower Don R.		0.6	0.1	0.0	0.0	0.0	0.0	171.0
Massey Creek		0.1	0.0	0.0	0.0	0.0	0.0	0.1
Upper Don R.	5	0.0	0.0	0.0	0.0	9.4	4.4	13.9
Middle Don R.		0.0	0.0	0.0	0.0	97.1	5.7	103.4
Lower Don R.		0.0	0.0	170.2	0.0	133.7	5.7	310.4
Massey Creek		0.0	0.0	0.0	0.0	13.1	0.0	13.1
Upper Don R.	10	0.0	0.0	0.0	0.0	18.7	8.8	27.7
Middle Don R.		0.0	0.0	0.0	5.0	194.1	11.4	211.2
Lower Don R.		0.0	0.0	170.2	43.8	267.5	11.4	493.7
Massey Creek		0.0	0.0	0.0	10.1	26.1	0.0	36.3
Upper Don R.	20	0.0	0.0	0.0	0.0	37.4	17.7	55.3
Middle Don R.		0.0	0.0	0.0	11.3	388.3	22.9	423.0
Lower Don R.		0.0	0.0	170.2	102.8	534.9	22.9	831.5
Massey Creek		0.0	0.0	0.0	26.9	52.2	0.0	79.2

TABLE 9

EXISTING COPPER LOADINGS
BY SOURCE REACH AND RAINFALL AMOUNT

	Rainfall Amount	DWF Urban	Copper DWF Rural	SOURCE STP	CSO	Urban Runoff	Rural Runoff	TOTAL
Upper Don R.	0	0.1	0.0	0.0	0.0	0.0	0.0	0.1
Middle Don R.		0.9	0.0	0.0	0.0	0.0	0.0	0.9
Lower Don R.		1.2	0.0	1.4	0.0	0.0	0.0	2.6
Massey Creek		0.1	0.0	0.0	0.0	0.0	0.0	0.1
Upper Don R.	5	0.0	0.0	0.0	0.0	1.0	0.1	1.2
Middle Don R.		0.0	0.0	0.0	0.0	10.7	0.1	1.2
Lower Don R.		0.0	0.0	1.4	0.0	14.7	0.1	17.4
Massey Creek		0.0	0.0	0.0	0.0	1.4	0.0	1.6
Upper Don R.	10	0.0	0.0	0.0	0.0	2.1	0.2	2.3
Middle Don R.		0.0	0.0	0.0	0.3	21.4	0.2	22.7
Lower Don R.		0.0	0.0	1.4	2.4	29.4	0.2	34.6
Massey Creek		0.0	0.0	0.0	0.5	2.9	0.0	3.6
Upper Don R.	20	0.0	0.0	0.0	0.0	4.1	0.4	4.6
Middle Don R.		0.0	0.0	0.0	0.6	42.7	0.5	44.7
Lower Don R.		0.0	0.0	1.4	5.5	58.8	0.5	67.4
Massey Creek		0.0	0.0	0.0	1.4	5.7	0.0	7.3

TABLE 10

EXISTING LEAD LOADINGS
BY SOURCE REACH AND RAINFALL AMOUNT

	Rainfall Amount	Lead DWF Urban	Lead DWF Rural	SOURCE STP	SOURCE CSO	Urban Runoff	Rural Runoff	TOTAL
Upper Don R.	0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Middle Don R.		0.1	0.0	0.0	0.0	0.0	0.0	0.1
Lower Don R.		0.1	0.0	1.4	0.0	0.0	0.0	1.5
Massey Creek		0.0	0.0	0.0	0.0	0.0	0.0	0.0
Upper Don R.	5	0.0	0.0	0.0	0.0	4.5	0.1	4.6
Middle Don R.		0.0	0.0	0.0	0.0	46.6	0.1	4.6
Lower Don R.		0.0	0.0	1.4	0.0	64.2	0.1	65.8
Massey Creek		0.0	0.0	0.0	0.0	6.3	0.0	6.3
Upper Don R.	10	0.0	0.0	0.0	0.0	9.0	0.1	9.1
Middle Don R.		0.0	0.0	0.0	0.9	93.2	0.2	94.4
Lower Don R.		0.0	0.0	1.4	8.0	128.4	0.2	138.0
Massey Creek		0.0	0.0	0.0	1.8	12.5	0.0	14.4
Upper Don R.	20	0.0	0.0	0.0	0.0	18.0	0.3	18.3
Middle Don R.		0.0	0.0	0.0	2.1	186.4	0.3	188.9
Lower Don R.		0.0	0.0	1.4	10.7	256.8	0.3	277.3
Massey Creek		0.0	0.0	0.0	4.9	25.1	0.0	30.0

TABLE 11

EXISTING FECAL COLIFORM LOADINGS
BY SOURCE REACH AND RAINFALL AMOUNT

	Rainfall Amount	DWF Urban	FC DWF Rural	SOURCE STP	CSO	Urban Runoff	Rural Runoff	TOTAL
Upper Don R.	0	13,932	136	0	0	0	0	14,068
Middle Don R.		130,059	176	0	0	0	0	130,235
Lower Don R.		185,097	176	116	0	0	0	185,389
Massey Creek		21,636	0	0	0	0	0	21,636
Upper Don R.	5	0	0	0	0	311,842	11,053	336,964
Middle Don R.		0	0	0	0	3,235,600	14,287	3,380,122
Lower Don R.		0	0	116	0	4,457,672	14,287	4,657,348
Massey Creek		0	0	0	0	435,347	0	456,983
Upper Don R.	10	0	0	0	0	623,685	22,106	659,859
Middle Don R.		0	0	0	1,320,965	6,471,199	28,573	7,950,973
Lower Don R.		0	0	116	11,537,391	8,915,344	28,573	20,660,698
Massey Creek		0	0	0	2,656,442	870,694	0	3,548,771
Upper Don R.	20	0	0	0	0	1,247,370	44,211	1,305,650
Middle Don R.		0	0	0	2,972,171	12,942,399	57,146	16,101,951
Lower Don R.		0	0	116	27,052,482	17,830,688	57,146	44,125,705
Massey Creek		0	0	0	7,083,844	1,741,388	0	8,846,868

TABLE 12

EXISTING INSTREAM CONCENTRATIONS
FROM SPREADSHEET MODELLING

REACH	Rainfall Condition	PARAMETER SS	TP	Ammonia	Copper	Lead	FC
Upper Don R.	0	5	0.19	0.01	0.006	0.002	700
Middle Don R.		5	0.27	0.01	0.016	0.002	2000
Lower Don R.		6	0.43	1.55	0.024	0.014	2000
Massey Creek		5	0.30	0.01	0.020	0.002	3000
Upper Don R.	5	188	0.19	0.19	0.015	0.056	4000
Middle Don R.		213	0.31	0.25	0.029	0.074	8000
Lower Don R.		204	0.34	0.53	0.300	0.113	8000
Massey Creek		215	0.33	0.26	0.031	0.124	9000
Upper Don R.	10	215	0.19	0.22	0.017	0.064	5000
Middle Don R.		229	0.32	0.28	0.030	0.083	12000
Lower Don R.		224	0.37	0.46	0.032	0.128	20000
Massey Creek		229	0.44	0.36	0.036	0.144	36000
Upper Don R.	20	231	0.20	0.23	0.018	0.069	5000
Middle Don R.		239	0.33	0.29	0.031	0.088	13000
Lower Don R.		235	0.37	0.40	0.033	0.135	22000
Massey Creek		236	0.48	0.41	0.038	0.153	45000
TARGET VALUE		200	0.03	?	0.005	0.025	100

REACH: UPPER DON RIVER CONDITION: DRY

COPPER

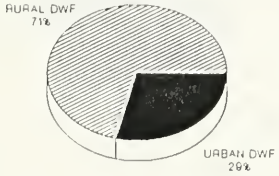
LOADING LESS THAN 1 KG/DAY FROM EACH SOURCE

LEAD

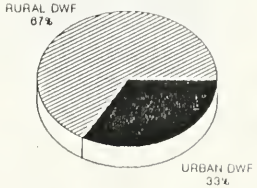
LOADING LESS THAN 1 KG/DAY FROM EACH SOURCE

FC

SS



TP



AMMONIA

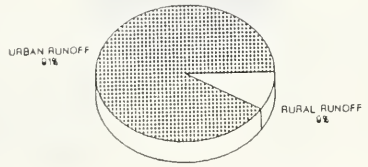
LOADING LESS THAN 1 KG/DAY FROM EACH SOURCE

RELATIVE SOURCE LOADINGS

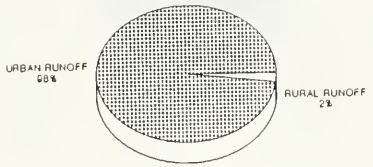
FIGURE 8

REACH: UPPER DON RIVER CONDITION: 5 mm STORM

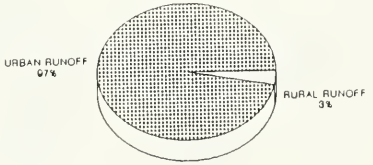
COPPER



LEAD



FC



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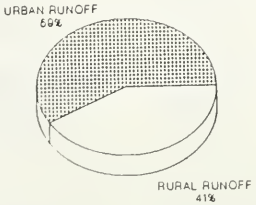

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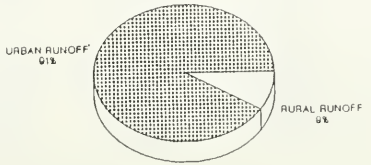
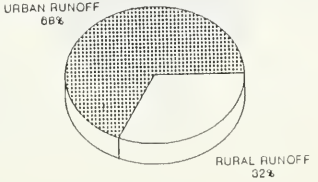


AMMONIA

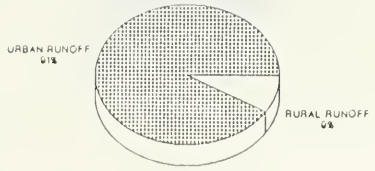


RELATIVE SOURCE LOADINGS

FIGURE 9

REACH: UPPER DON RIVER CONDITION: 10 mm STORM

COPPER



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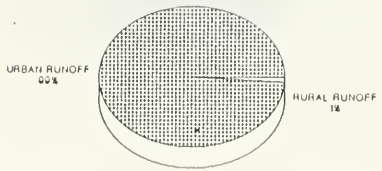
LEAD



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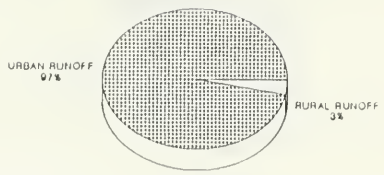

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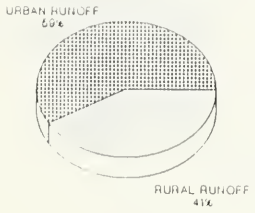
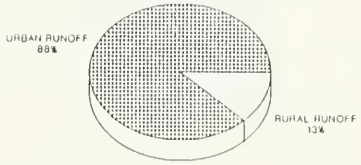
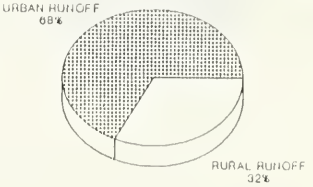




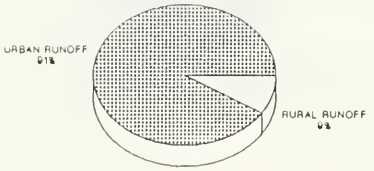


RELATIVE SOURCE LOADINGS

FIGURE 10

REACH: UPPER DON RIVER CONDITION: 20 MM STORM

COPPER



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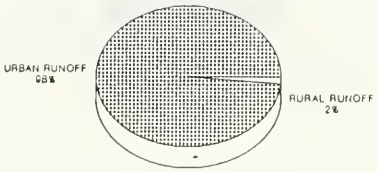
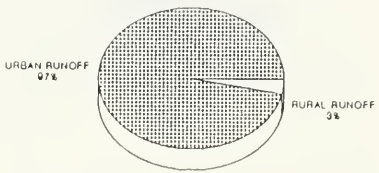
LEAD



TP

FC



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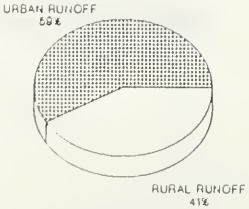
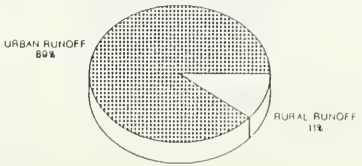
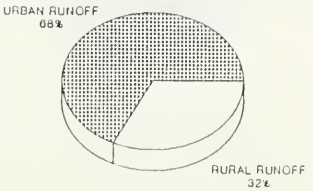






RELATIVE SOURCE LOADINGS

FIGURE 11

REACH: MIDDLE DON RIVER CONDITION: DRY

COPPER

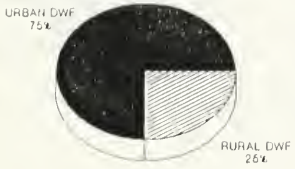
LOADINGS LESS THAN 1 KG/DAY FROM EACH SOURCE

LEAD

LOADING LESS THAN 1 KG/DAY FROM EACH SOURCE

FC

SS



TP

AMMONIA

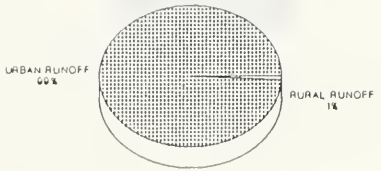
LOADINGS LESS THAN 1 KG/DAY FROM EACH SOURCE

RELATIVE SOURCE LOADINGS

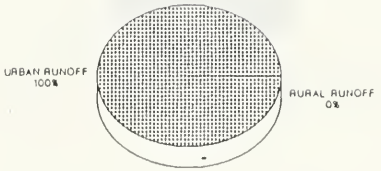
FIGURE 12

REACH: MIDDLE DON RIVER CONDITION: 5 MM STORM

COPPER



LEAD



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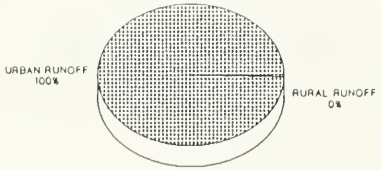

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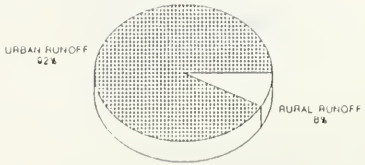

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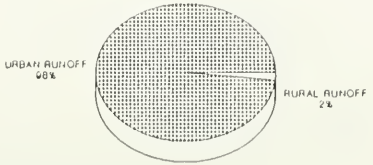


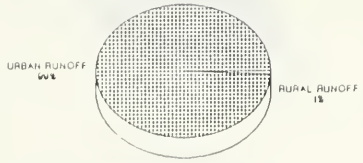
AMMONIA

RELATIVE SOURCE LOADINGS FIGURE 13

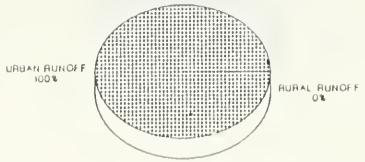
REACH: MIDDLE DON RIVER

CONDITION: 10 MM STORM

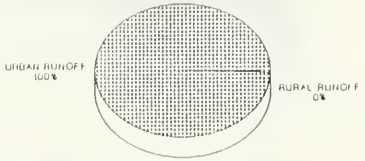
COPPER



LEAD



FC



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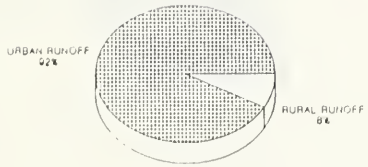

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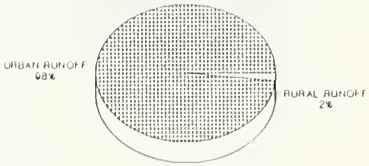


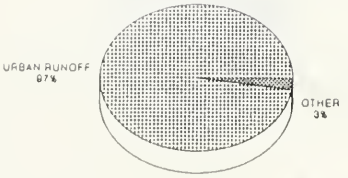
AMMONIA

RELATIVE SOURCE LOADINGS

FIGURE 14

REACH: MIDDLE DON RIVER CONDITION: 20 MM STORM

COPPER LEAD FC



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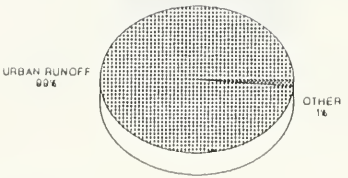

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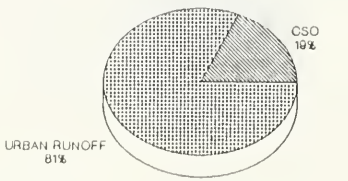

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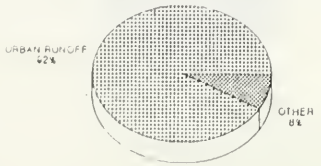
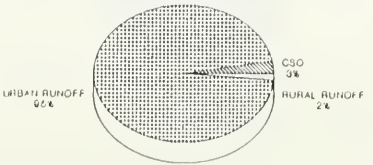
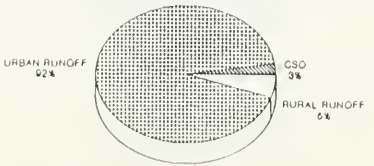




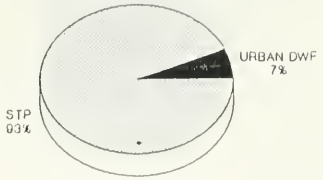


RELATIVE SOURCE LOADINGS FIGURE 15

REACH: LOWER DON RIVER CONDITION: DRY

COPPER LEAD FC

SS



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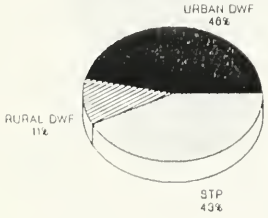
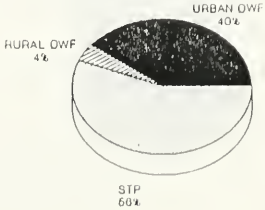
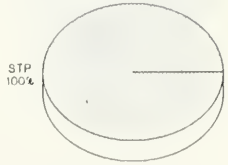
AMMONIA



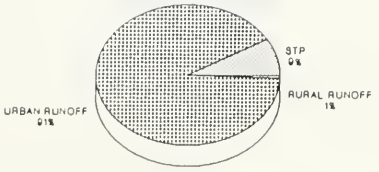




RELATIVE SOURCE LOADINGS FIGURE 16

REACH: LOWER DON RIVER CONDITION: 5MM STORM

CU



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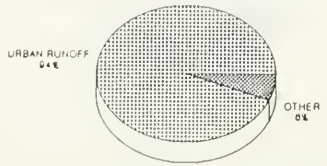
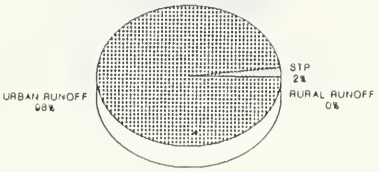


LEAD



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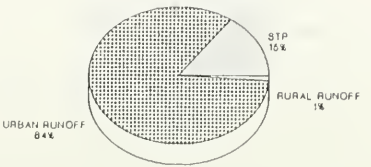
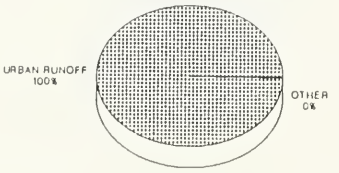
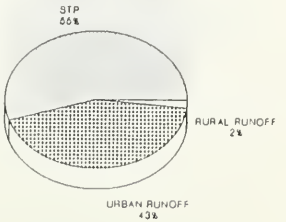


FC



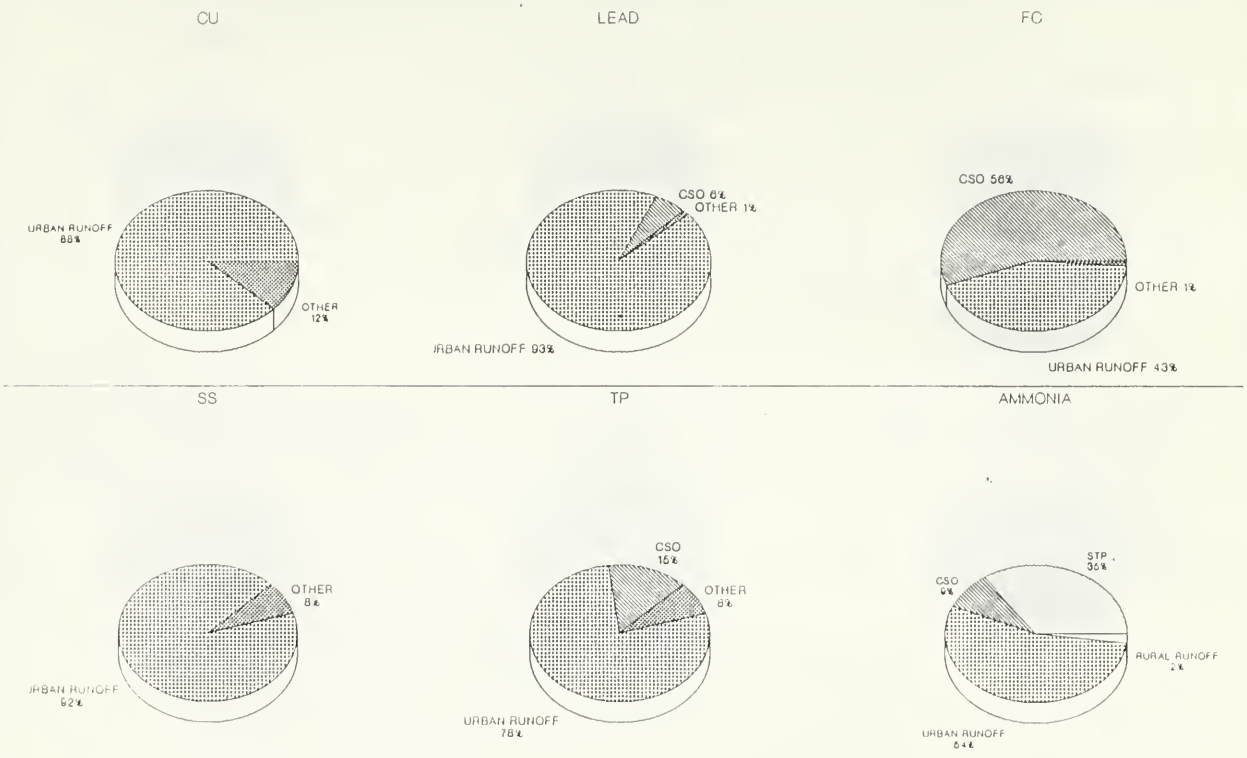
AMMONIA



RELATIVE SOURCE LOADINGS

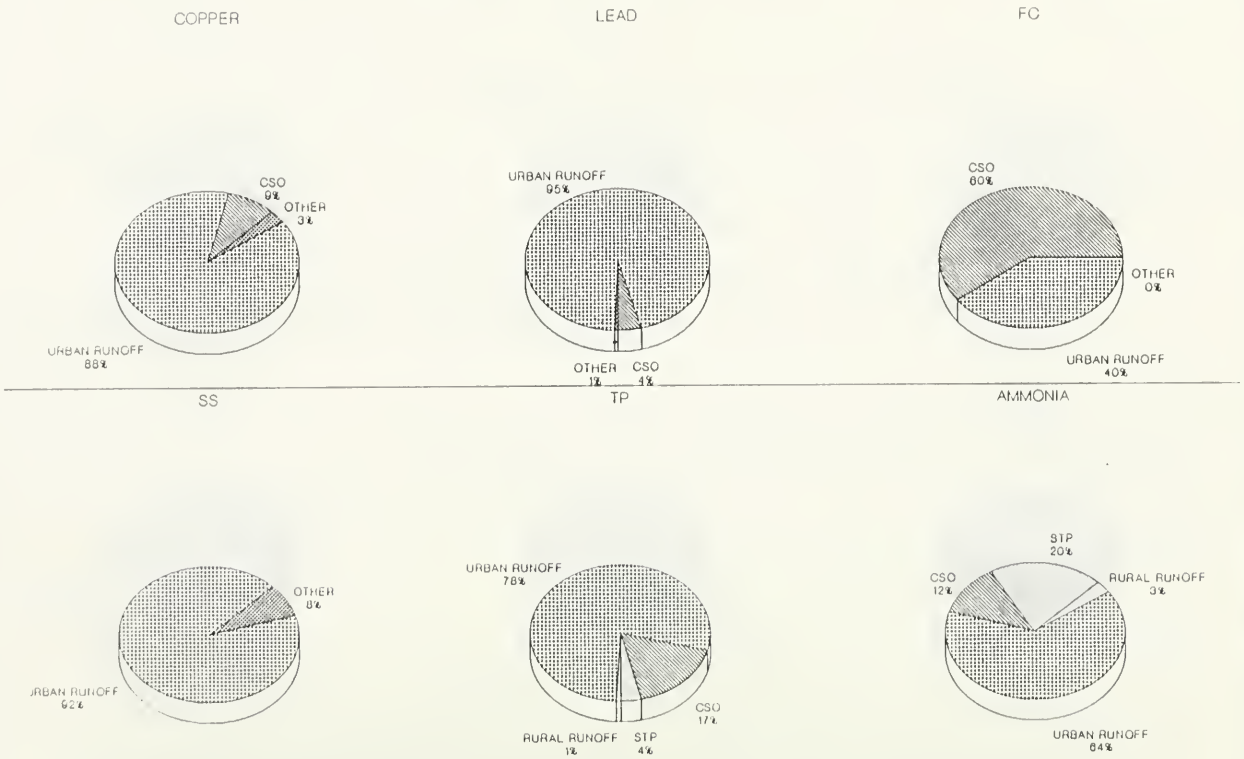
FIGURE 17

REACH: LOWER DON RIVER CONDITIONS: 10 MM STORM



RELATIVE SOURCE LOADINGS FIGURE 18

REACH: LOWER DON RIVER CONDITION: 20 MM STORM



RELATIVE SOURCE LOADINGS FIGURE 19

REACH: MASSEY CREEK CONDITION: DRY

COPPER

LOADING LESS THAN 1 KG/DAY FROM EACH SOURCE

LEAD

LOADING LESS THAN 1 KG/DAY FROM EACH SOURCE

FC

SS

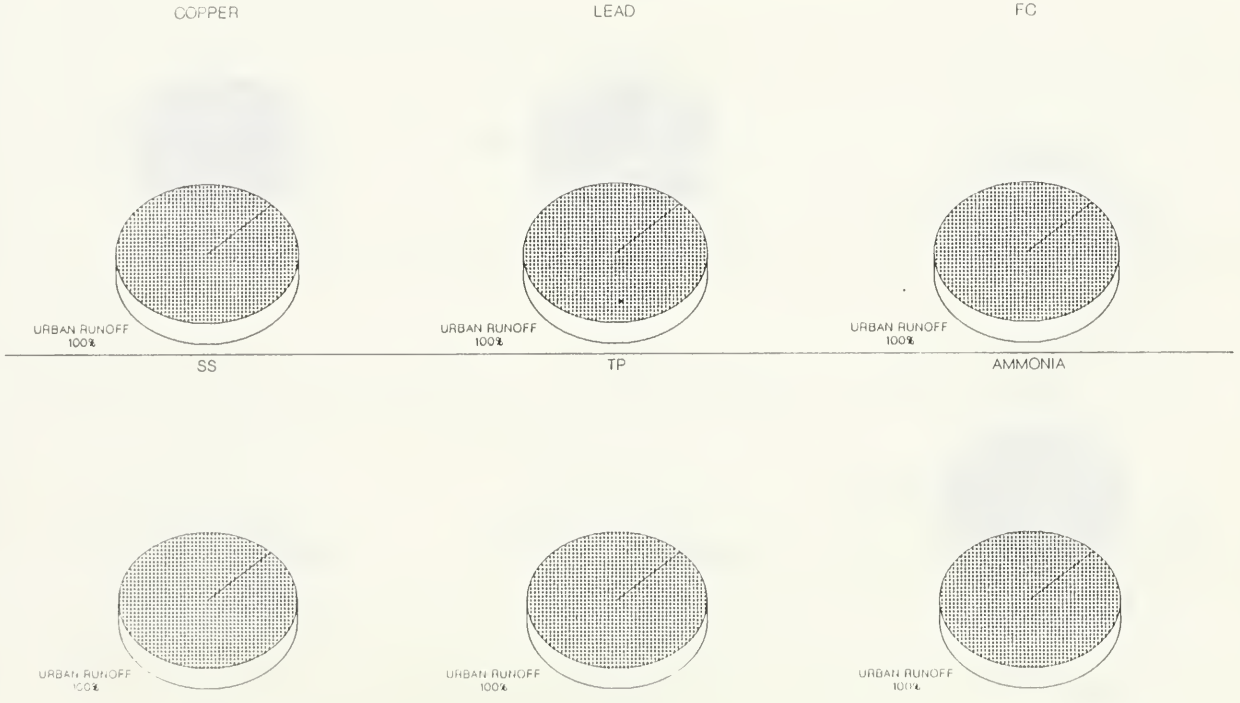
TP

AMMONIA

LOADING LESS THAN 1 KG/DAY FROM EACH SOURCE

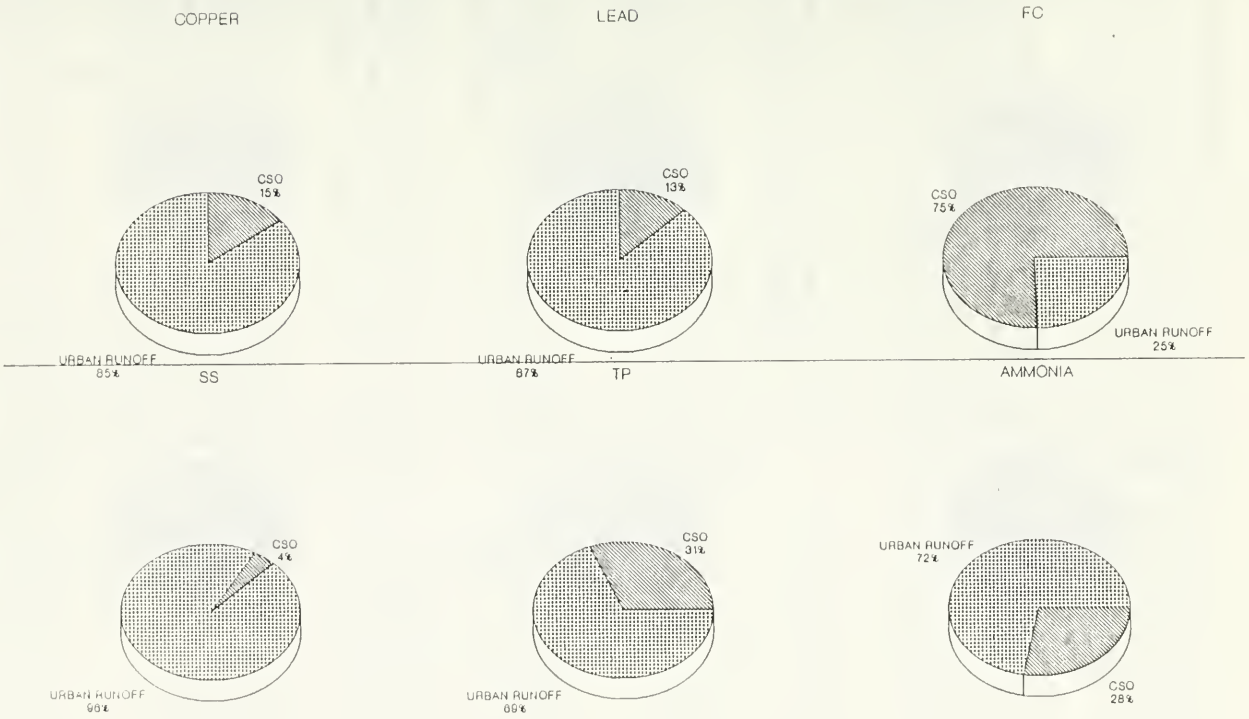
RELATIVE SOURCE LOADINGS FIGURE 20

REACH: MASSEY CREEK CONDITION: 5 MM STORM



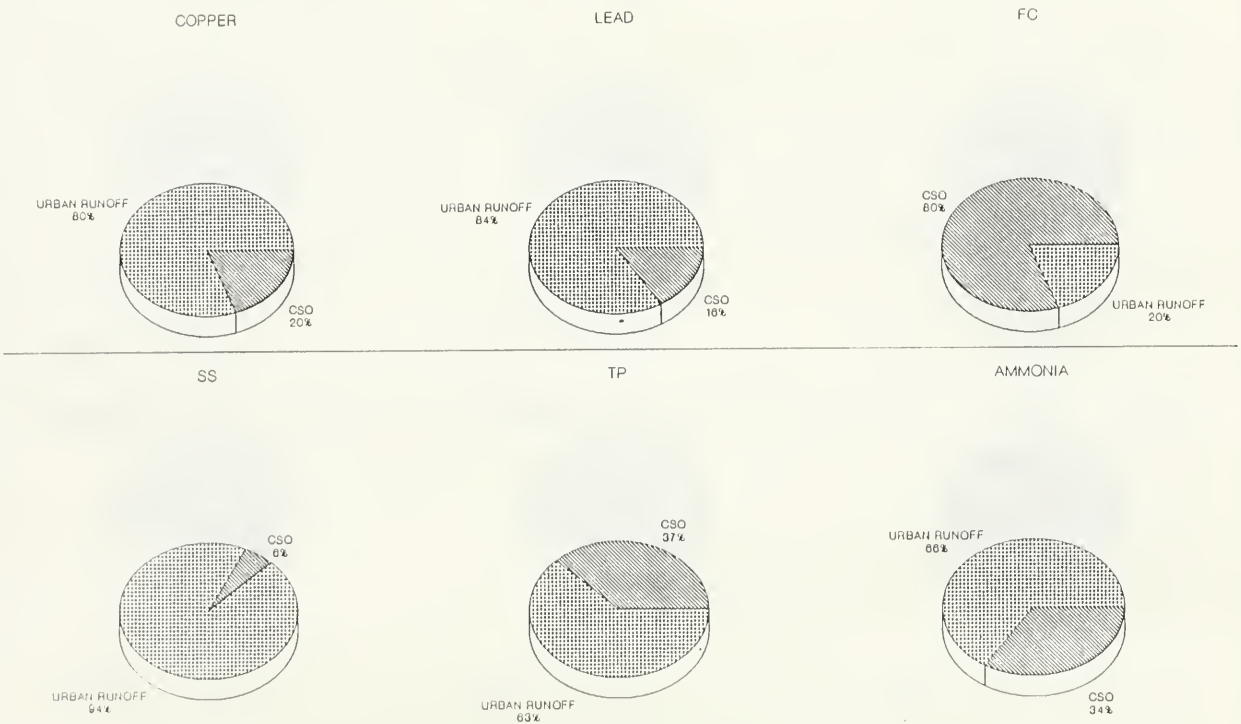
RELATIVE SOURCE LOADINGS FIGURE 21

REACH: MASSEY CREEK CONDITION: 10 MM STORM



RELATIVE SOURCE LOADINGS FIGURE 22

REACH: MASSEY CREEK CONDITION: 20 MM STORM



RELATIVE SOURCE LOADINGS FIGURE 23

1. The concentrations are lowest in the upper Don River and increase downstream; this may be attributed to the fact that the upstream land uses are a mixture of rural and urban, while the lower catchments are fully developed; furthermore, the North Toronto STP and combined sewer overflows discharge flows in the lower reach;

2. the concentrations, for a given condition, increase by a factor of 1 to 3-fold, from the upstream to middle reach and by and additional 1 to 10-fold from the mid to lower reach; Massey Creek, a heavily urbanized catchment with combined sewer overflows and industrial areas has concentrations of approximately 2 to 10-fold higher than the upper Don which is the least developed watershed;

3. the concentrations are lowest for dry weather conditions and increase by a factor of 1 to 30 for wet weather conditions;

4. the lower Don, during either dry or wet weather conditions, is the only stretch of river which is likely to produce excessive levels of potentially toxic substances, e.g., ammonia, copper and lead.

The results were also used to compare instream concentrations to target values. For this study, target values are defined as concentrations which would, from a water quality perspective, support specified beneficial uses. The findings show that, on average:

1. suspended solids concentrations are well below the target value for dry weather conditions at all locations and are in the range of the target value for wet weather conditions; the target value reflects a fishery end use, not an aesthetic end use;

2. total phosphorus concentrations during dry weather conditions are highest in the lower Don due to the STP (four times target value); the concentrations in the upstream reach are in the vicinity of the target value during dry weather conditions. For wet weather conditions, the concentrations exceed the target value by 2-fold in the upper reach and by 4-fold in the lower reach;

3. ammonia concentrations are well below target values for all of the river system except downstream of the wastewater treatment plant. There, the concentrations approach, but are still below target values during wet and dry weather conditions;

4. copper concentrations, during dry weather conditions, are also in the vicinity of the target value in the upstream reach; the concentrations in the lower Don increase by a factor of five. During wet weather, the exceedances vary from a factor of 3 to 6 for the upper and lower Don reaches, respectively;

5. lead concentrations are generally below, or in the vicinity of the target value for dry weather conditions; for wet weather, the concentrations are about twice the level at the downstream reach as compared to values in the upstream reach; furthermore, they exceed the target value by 2 to 5-fold in the upper and lower reaches respectively;

6. fecal coliform concentrations always exceed the target value by a considerable amount; the exceedances range from approximately 10-fold for dry weather (upper Don) to 250-fold for wet weather in the lower reach; Massey Creek wet weather conditions are higher than the Don River concentrations due to the combined sewer overflow loadings.

5.0 CONTROL OPTIONS

5.1 Control Option Scenario's Considered

The basis of the above work was to establish a methodology whereby the effectiveness of control options could be tested and compared to each other and to the levels of water quality desired by the Stakeholders. The effectiveness of the various control options was checked for individual options and in combination with each other. Details about these control options can be found in OME (1986), Supporting Document 3, and Schueler (1986).

The control options and combinations of options tested are listed below. A considerable amount of effort was put into evaluating control options which would reduce pollutant loads from storm sewer systems, as the above analysis showed that this source produced a majority of the pollutant loadings.

1. North Toronto STP upgrade
2. North Toronto STP removal
3. combined sewer overflow control
4. urban stormwater management ponds, both inline and offline
5. urban and rural wet and dry maintenance practices
6. urban and rural wet and dry best management practices
7. flow reduction through redevelopment or infiltration of surface water into ground water
8. options 4 and 7 combined
9. items 2 through 7 inclusive

This list represents only those options which were dealt with in a quantitative manner. Several other control options were considered in a qualitative manner as part of the overall study. These options are discussed in Supporting Documents 2 and 3.

In practice, the overall effectiveness of each control option will be determined by the level of implementation. Modelling each possible degree of implementation or combination of control options was neither attempted or required. The primary objective of the analyses was to assist in prioritizing remedial options, to establish the relative effectiveness of the various control options and to obtain some perspective as to how beneficial they are with respect to attaining Stakeholder objectives. In general a fairly

typical level of control for each option was considered for application on a watershed wide basis.

For each of the control options the removal factors given in Table 13 for each parameter were used. These removal factors were obtained from various literature sources. Other control options, such as CSO reduction, required the control of discharge volumes.

The control options considered in this study will impact either the concentration or the volume of water discharged to the river. The "North Toronto STP removal" completely removes the STP effluent from the river. Hence, the flow reduction factor (R_2) is assigned a value of 1 (see Table 13b) while the discharge concentration is not affected. CSO control is assumed to remove 90% of the volume of water presently discharged to the watershed. Urban infiltration control induces infiltration of stormwater runoff into the ground. Assuming that all the infiltrating water eventually returns to the watershed, one would assign the reduction factor for flow (R_2) equal to 0, and the reduction factor for concentration, (R_1), equal to 0.6, assuming that 50% of urban runoff infiltrates first to the ground. In this work, an alternative approach was used for evaluation of events by assigning $R_1 = 0$ and $R_2 = 0.6$. This assumes that infiltrating rain water does not reach the river during the time scale of the event.

The other removal factors for concentration are based upon the following assumptions. For an STP upgrade, a variety of methods can be used. Most would involve extra treatment units (Gore and Storrie, 1987). It was assumed that additional injection of chemicals to precipitate more phosphorus (perhaps two stage injection) and partial nitrification of the effluent would result in the removals given in Table 13a. It was assumed that clarifier improvements would not substantially change the removal of suspended solids and metals. It was also assumed that chlorination would not become significantly more efficient since present operating data indicate low values for the number of bacti discharged in the effluent to the river.

The removal factors for SWM ponds, maintenance and BMP's are based upon field data from the NURP (National Urban Runoff Program) monitoring program in the U.S. (Driscoll, 1986a, b) and TAWMS estimates (MOE, 1986). Bacterial removals in ponds range from negligible to more than 90% (with residence times of 2-4 days). Assuming that space limitations will preclude the large sizes of ponds required to achieve these

TABLE 13a: REMOVAL FACTOR (R_1) FOR CONCENTRATION

Option	SS	TP	Ammonia	Copper	Lead	FC
1. North Toronto STP Upgrade	0	0.4	0.5	0.0	0.0	0.0
2. North Toronto STP Removal	0.0	0.0	0.0	0.0	0.0	0.0
3. CSO Control	0.0	0.0	0.0	0.0	0.0	0.0
4. SWM (Wet) Ponds	0.8	0.5	0.2	0.4	0.7	0.2
5. Urban/Rural Maintenance	0.1	0.1	0.1	0.1	0.1	0.1
6. Urban/Rural BMP's	0.3	0.3	0.0	0.3	0.3	0.9
7. Urban Infiltration Control	0.0	0.0	0.0	0.0	0.0	0.0

TABLE 13b: REDUCTION FACTORS FOR FLOW

	Control Option	Reduction Factor (R_2)
1.	North Toronto STP Upgrade	0.0
2.	North Toronto STP Removal	1.0
3.	CSO Control	0.9
4.	SWM Ponds	0.0
5.	Urban/Rural Maintenance	0.0
6.	Urban/Rural BMP's	0.0
7.	Urban Infiltration Control	0.6

Formula Used:
$$C_{RIVER} = \frac{SSS(C_{SOURCE}(1-R_1)(1-R_3) \cdot Q_{SOURCE}(1-R_2))}{SSS(Q_{SOURCE}(1-R_2))}$$

(Note: SSS = sum of all terms)

R_3 = instream removal due to bacterial decay.

long residence times, a small removal factor is assigned. The impact of this variable was further tested by sensitivity analyses (assuming R_I = 0.9 for fecal coliforms).

5.2 Control Option Effectiveness

For each parameter, and for each condition dry through wet each of the various control options were tested to identify the resulting source loadings and instream river concentrations. The resulting instream concentrations were compared to those for existing condition and to target values or water quality objectives. These data are presented in Tables 14 through 17.

The effectiveness of the various control options varies between reaches, conditions and parameter. Briefly stated, the findings showed that:

Wet Weather Conditions

1. urban wet ponds and flow reduction through re-development are the most effective options for reducing the concentrations of all parameters. Collectively, implementing both options would reduce the concentrations during most rainfall events to values approaching the target value for suspended solids, total phosphorus, copper and lead;

2. upgrading or removing the STP or eliminating combined sewer overflows are not as effective as the above options on a watershed scale; and

3. fecal coliform values are improved, but additional control is required to achieve target values.

Dry Weather Conditions

1. the construction of wet ponds or implementation of flow techniques would likely be beneficial in reducing concentrations of most parameters in the upper and mid reaches.

2. upgrading or the removal of the North Toronto STP is effective in reducing total

phsophorus ammonia, copper and lead within the lower reach.

TABLE 14

CONTROL OPTION SUMMARIES — BASED ON 50th PERCENTILE EXISTING CONCENTRATIONS

DON RIVER REACH: UPPER DON RIVER
PRECIPITATION CONDITIONS: DRY

		CONCENTRATIONS (mg/l) PARAMETER					
	OPTION	SS	TP	AMMONIA	COPPER	LEAD	FC
1	STP UPGRADE	5	0.19	0.01	0.006	0.002	700
2	STP REMOVAL	5	0.19	0.01	0.006	0.002	700
3	CSO 90% REMOVAL	5	0.19	0.01	0.006	0.002	700
4A	URBAN OFFLINE WET PONDS	5	0.19	0.01	0.006	0.002	700
4B	URBAN/RURAL INLINE POND	5	0.19	0.01	0.006	0.002	700
5	URBAN AND RURAL WET AND DRY MAINTENANCE	5	0.17	0.01	0.005	0.002	700
6	URBAN AND RURAL WET AND DRY BMP	4	0.14	0.01	0.005	0.001	700
7	URBAN FLOW CONTROL	5	0.19	0.01	0.006	0.002	700
8	URBAN OFFLINE PONDS AND FLOW CONTROL	5	0.19	0.01	0.006	0.002	700
9	ALL (3-7) WITH STP REMOVAL	3	0.10	0.01	0.003	0.001	500
	EXISTING	5	0.19	0.01	0.006	0.002	700
	TARGET VALUE	200	0.10		0.005	0.025	100

DON RIVER REACH: MIDDLE DON RIVER
PRECIPITATION CONDITIONS: DRY

	CONCENTRATIONS (mg/l) PARAMETER					
OPTION	SS	TP	AMMONIA	COPPER	LEAD	FC
1 STP UPGRADE	5	0.27	0.01	0.016	0.002	2000
2 STP REMOVAL	5	0.27	0.01	0.016	0.002	2000
3 CSO 90% REMOVAL	5	0.27	0.01	0.016	0.002	2000
4A URBAN OFFLINE WET PONDS	5	0.27	0.01	0.016	0.002	2000
4B URBAN/RURAL INLINE POND	5	0.27	0.01	0.016	0.002	2000
5 URBAN AND RURAL WET AND DRY MAINTENANCE	5	0.24	0.01	0.015	0.002	1900
6 URBAN AND RURAL WET AND DRY BMP	4	0.24	0.01	0.015	0.002	2000
7 URBAN FLOW CONTROL	5	0.27	0.01	0.016	0.002	2000
8 URBAN OFFLINE PONDS AND FLOW CONTROL	5	0.27	0.01	0.016	0.002	2000
9 ALL (3-7) WITH STP REMOVAL	1	0.12	0.01	0.008	0.001	1500
EXISTING	5	0.27	0.01	0.016	0.002	2000
TARGET VALUE	200	0.10		0.005	0.025	100

DON RIVER REACH: UPPER DON RIVER
PRECIPITATION CONDITIONS: 5 mm

		CONCENTRATIONS (mg/l) PARAMETER					
	OPTION	SS	TP	AMMONIA	COPPER	LEAD	FC
1	STP UPGRADE	188	0.19	0.19	0.015	0.056	4000
2	STP REMOVAL	188	0.19	0.19	0.015	0.056	4000
3	CSO 90% REMOVAL	188	0.19	0.19	0.015	0.056	4000
4A	URBAN OFFLINE WET PONDS	113	0.13	0.17	0.010	0.018	3000
4B	URBAN/RURAL INLINE POND	39	0.12	0.15	0.010	0.017	3000
5	URBAN AND RURAL WET AND DRY MAINTENANCE	170	0.17	0.17	0.014	0.050	4000
6	URBAN AND RURAL WET AND DRY BMP	151	0.16	0.18	0.013	0.050	4000
7	URBAN FLOW CONTROL 80%	113	0.19	0.10	0.005	0.012	1000
8	URBAN OFFLINE PONDS AND FLOW CONTROL	98	0.13	0.09	0.004	0.005	1000
9	ALL (3-7) WITH STP REMOVAL	62	0.09	0.08	0.003	0.004	600
	EXISTING	188	0.19	0.19	0.015	0.056	4000
	TARGET VALUE	200	0.10		0.005	0.025	100

DON RIVER REACH: MIDDLE DON RIVER
PRECIPITATION CONDITIONS: 5 mm

	CONCENTRATIONS (mg/l) PARAMETER					
OPTION	SS	TP	AMMONIA	COPPER	LEAD	FC
1 STP UPGRADE	213	0.31	0.25	0.029	0.114	8000
2 STP REMOVAL	213	0.31	0.25	0.029	0.114	8000
3 CSO 90% REMOVAL	213	0.31	0.25	0.029	0.114	8000
4A URBAN OFFLINE WET PONDS	55	0.18	0.20	0.018	0.035	7000
4B URBAN/RURAL INLINE POND	43	0.17	0.20	0.018	0.034	7000
5 URBAN AND RURAL WET AND DRY MAINTENANCE	191	0.27	0.22	0.026	0.103	7000
6 URBAN AND RURAL WET AND DRY BMP	188	0.27	0.23	0.026	0.103	7000
7 URBAN FLOW CONTROL 80%	55	0.11	0.06	0.008	0.023	2000
8 URBAN OFFLINE PONDS AND FLOW CONTROL	23	0.08	0.05	0.006	0.007	2000
9 ALL (3-7) WITH STP REMOVAL	16	0.05	0.04	0.004	0.006	1000
EXISTING	213	0.31	0.25	0.029	0.074	8000
TARGET VALUE	200	0.10		0.005	0.025	100

NOTES: UNITS FOR FECAL COLIFORM ARE counts/100ml

CONTROL OPTION SUMMARIES — BASED ON 50th PERCENTILE EXISTING CONCENTRATIONS

DON RIVER REACH: LOWER DON RIVER
PRECIPITATION CONDITIONS: DRY

		CONCENTRATIONS (mg/l)					
		PARAMETER					
	OPTION	SS	TP	AMMONIA	COPPER	LEAD	FC
1	STP UPGRADE	6	0.34	0.76	0.014	0.014	2000
2	STP REMOVAL	3	0.19	0.01	0.011	0.001	2000
3	CSO 90% REMOVAL	6	0.43	1.55	0.024	0.014	2000
4A	URBAN OFFLINE WET PONDS	6	0.43	1.55	0.024	0.014	2000
4B	URBAN/RURAL INLINE POND	6	0.43	1.55	0.024	0.014	2000
5	URBAN AND RURAL WET AND DRY MAINTENANCE	6	0.42	1.55	0.023	0.014	2000
6	URBAN AND RURAL WET AND DRY BMP	6	0.41	1.55	0.022	0.014	2000
7	URBAN FLOW CONTROL	6	0.43	1.55	0.024	0.014	2000
8	URBAN OFFLINE PONDS AND FLOW CONTROL	6	0.43	1.55	0.024	0.014	2000
9	ALL (3-7) WITH STP REMOVAL	1	0.08	<.01	0.006	<.001	1000
	EXISTING	6	0.43	1.55	0.024	0.014	2000
	TARGET VALUE	200	0.10		0.005	0.025	100

DON RIVER REACH: MASSEY CREEK
PRECIPITATION CONDITIONS: DRY

		CONCENTRATIONS (mg/l)					
		PARAMETER					
	OPTION	SS	TP	AMMONIA	COPPER	LEAD	FC
1	STP UPGRADE	5	0.30	0.01	0.020	0.002	3000
2	STP REMOVAL	5	0.30	0.01	0.020	0.002	3000
3	CSO 90% REMOVAL	5	0.30	0.01	0.020	0.002	3000
4A	URBAN OFFLINE WET PONDS	5	0.30	0.01	0.020	0.002	3000
4B	URBAN/RURAL INLINE POND	5	0.30	0.01	0.020	0.002	3000
5	URBAN AND RURAL WET AND DRY MAINTENANCE	5	0.27	0.01	0.018	0.002	3000
6	URBAN AND RURAL WET AND DRY BMP	5	0.27	0.01	0.018	0.002	3000
7	URBAN FLOW CONTROL	5	0.30	0.01	0.020	0.002	3000
8	URBAN OFFLINE PONDS AND FLOW CONTROL	5	0.30	0.01	0.020	0.002	3000
9	ALL (3-7) WITH STP REMOVAL	0	0.12	0.01	0.010	<.001	2000
	EXISTING	5	0.30	0.01	0.020	0.002	3000
	TARGET VALUE	200	0.10		0.005	0.025	100

DON RIVER REACH: LOWER DON RIVER
PRECIPITATION CONDITIONS: 5 mm

		CONCENTRATIONS (mg/l)					
		PARAMETER					
	OPTION	SS	TP	AMMONIA	COPPER	LEAD	FC
1	STP UPGRADE	204	0.32	0.39	0.030	0.113	8000
2	STP REMOVAL	203	0.29	0.24	0.027	0.110	8000
3	CSO 90% REMOVAL	204	0.34	0.53	0.030	0.113	8000
4A	URBAN OFFLINE WET PONDS	51	0.21	0.49	0.020	0.036	6000
4B	URBAN/RURAL INLINE POND	42	0.21	0.48	0.020	0.036	6000
5	URBAN AND RURAL WET AND DRY MAINTENANCE	184	0.31	0.51	0.027	0.101	7000
6	URBAN AND RURAL WET AND DRY BMP	181	0.31	0.51	0.027	0.101	7000
7	URBAN FLOW CONTROL 80%	51	0.14	0.35	0.010	0.025	2000
8	URBAN OFFLINE PONDS AND FLOW CONTROL	21	0.11	0.34	0.008	0.009	2000
9	ALL (3-7) WITH STP REMOVAL	14	0.04	0.04	0.004	0.005	1000
	EXISTING	204	0.34	0.53	0.300	0.113	8000
	TARGET VALUE	200	0.10		0.005	0.025	100

NOTES. UNITS FOR FECAL COLIFORM ARE counts/100ml.

DON RIVER REACH: MASSEY CREEK
PRECIPITATION CONDITIONS: 5 mm

		CONCENTRATIONS (mg/l)					
		PARAMETER					
	OPTION	SS	TP	AMMONIA	COPPER	LEAD	FC
1	STP UPGRADE	215	0.33	0.26	0.031	0.124	9000
2	STP REMOVAL	215	0.33	0.26	0.031	0.124	9000
3	CSO 90% REMOVAL	215	0.33	0.26	0.031	0.124	9000
4A	URBAN OFFLINE WET PONDS	44	0.18	0.21	0.020	0.037	7000
4B	URBAN/RURAL INLINE POND	44	0.18	0.21	0.020	0.037	7000
5	URBAN AND RURAL WET AND DRY MAINTENANCE	194	0.29	0.23	0.028	0.111	8000
6	URBAN AND RURAL WET AND DRY BMP	194	0.29	0.23	0.028	0.111	8000
7	URBAN FLOW CONTROL 80%	44	0.10	0.05	0.009	0.025	2000
8	URBAN OFFLINE PONDS AND FLOW CONTROL	9	0.07	0.04	0.006	0.008	2000
9	ALL (3-7) WITH STP REMOVAL	7	0.04	0.03	0.004	0.006	1000
	EXISTING	215	0.33	0.26	0.031	0.124	9000
	TARGET VALUE	200	0.10		0.005	0.025	100

TABLE 16

DON RIVER REACH: UPPER DON RIVER
PRECIPITATION CONDITIONS: 10 mm

OPTION	CONCENTRATIONS (mg/l) PARAMETER SS	TP	AMMONIA	COPPER	LEAD	FC
1 STP UPGRADE	215	0.19	0.22	0.017	0.064	5000
2 STP REMOVAL	215	0.19	0.22	0.017	0.064	5000
3 CSO 90% REMOVAL	215	0.19	0.22	0.017	0.064	5000
4A URBAN OFFLINE WET PONDS	128	0.12	0.19	0.011	0.020	4000
4B URBAN/RURAL INLINE POND	44	0.11	0.17	0.010	0.019	4000
5 URBAN AND RURAL WET AND DRY MAINTENANCE	193	0.18	0.19	0.015	0.057	4000
6 URBAN AND RURAL WET AND DRY BMP	172	0.17	0.20	0.015	0.057	4000
7 URBAN FLOW CONTROL 60%	150	0.19	0.14	0.008	0.026	2000
8 URBAN OFFLINE PONDS AND FLOW CONTROL	115	0.12	0.13	0.006	0.009	2000
9 ALL (3-7) WITH STP REMOVAL	74	0.09	0.11	0.004	0.007	1000
EXISTING	215	0.19	0.22	0.017	0.064	5000
TARGET VALUE	200	0.10		0.005	0.025	100

DON RIVER REACH: MIDDLE DON RIVER
PRECIPITATION CONDITIONS: 10 mm

OPTION	CONCENTRATIONS (mg/l) PARAMETER SS	TP	AMMONIA	COPPER	LEAD	FC
1 STP UPGRADE	229	0.32	0.28	0.030	0.125	12000
2 STP REMOVAL	229	0.32	0.28	0.030	0.125	12000
3 CSO 90% REMOVAL	228	0.31	0.27	0.030	0.123	9000
4A URBAN OFFLINE WET PONDS	60	0.18	0.23	0.019	0.039	11000
4B URBAN/RURAL INLINE POND	47	0.18	0.23	0.019	0.039	11000
5 URBAN AND RURAL WET AND DRY MAINTENANCE	207	0.29	0.25	0.027	0.113	11000
6 URBAN AND RURAL WET AND DRY BMP	203	0.29	0.26	0.027	0.113	11000
7 URBAN FLOW CONTROL 60%	102	0.17	0.13	0.014	0.052	7000
8 URBAN OFFLINE PONDS AND FLOW CONTROL	34	0.11	0.11	0.009	0.018	7000
9 ALL (3-7) WITH STP REMOVAL	24	0.06	0.08	0.006	0.012	3000
EXISTING	229	0.32	0.28	0.030	0.088	12000
TARGET VALUE	200	0.10		0.005	0.025	100

DON RIVER REACH: UPPER DON RIVER
PRECIPITATION CONDITIONS: 20 mm

OPTION	CONCENTRATIONS (mg/l) PARAMETER SS	TP	AMMONIA	COPPER	LEAD	FC
1 STP UPGRADE	231	0.20	0.23	0.018	0.069	5000
2 STP REMOVAL	231	0.20	0.23	0.018	0.069	5000
3 CSO 90% REMOVAL	231	0.20	0.23	0.018	0.069	5000
4A URBAN OFFLINE WET PONDS	138	0.12	0.20	0.011	0.022	4000
4B URBAN/RURAL INLINE POND	47	0.10	0.19	0.011	0.021	4000
5 URBAN AND RURAL WET AND DRY MAINTENANCE	208	0.18	0.21	0.016	0.062	4000
6 URBAN AND RURAL WET AND DRY BMP	131	0.12	0.17	0.009	0.016	3000
7 URBAN FLOW CONTROL 30%	196	0.20	0.19	0.013	0.048	4000
8 URBAN OFFLINE PONDS AND FLOW CONTROL	84	0.08	0.12	0.009	0.017	3000
9 ALL (3-7) WITH STP REMOVAL	84	0.08	0.12	0.007	0.012	2000
EXISTING	231	0.20	0.23	0.018	0.069	5000
TARGET VALUE	200	0.10		0.005	0.025	100

DON RIVER REACH: MIDDLE DON RIVER
PRECIPITATION CONDITIONS: 20 mm

OPTION	CONCENTRATIONS (mg/l) PARAMETER SS	TP	AMMONIA	COPPER	LEAD	FC
1 STP UPGRADE	239	0.33	0.29	0.031	0.130	13000
2 STP REMOVAL	239	0.33	0.29	0.031	0.130	13000
3 CSO 90% REMOVAL	238	0.31	0.26	0.030	0.128	9000
4A URBAN OFFLINE WET PONDS	62	0.18	0.24	0.019	0.041	11000
4B URBAN/RURAL INLINE POND	49	0.18	0.24	0.019	0.041	11000
5 URBAN AND RURAL WET AND DRY MAINTENANCE	215	0.30	0.27	0.028	0.118	12000
6 URBAN AND RURAL WET AND DRY BMP	49	0.14	0.18	0.014	0.013	9000
7 URBAN FLOW CONTROL 30%	173	0.25	0.22	0.022	0.092	11000
8 URBAN OFFLINE PONDS AND FLOW CONTROL	45	0.12	0.14	0.015	0.031	6000
9 ALL (3-7) WITH STP REMOVAL	35	0.09	0.13	0.011	0.022	5000
EXISTING	239	0.33	0.29	0.031	0.088	13000
TARGET VALUE	200	0.10		0.005	0.025	100

NOTES: UNITS FOR FECAL COLIFORM ARE counts/100ml

DON RIVER REACH: LOWER DON RIVER
PRECIPITATION CONDITIONS: 10 mm

CONCENTRATIONS (mg/l)

	OPTION	PARAMETER SS	TP	AMMONIA	COPPER	LEAD	FC
1	STP UPGRADE	224	0.36	0.38	0.032	0.128	20000
2	STP REMOVAL	223	0.35	0.30	0.031	0.126	20000
3	CSO 90% REMOVAL	220	0.32	0.42	0.030	0.121	10000
4A	URBAN OFFLINE WET PONDS	59	0.23	0.41	0.021	0.045	17000
4B	URBAN/RURAL INLINE POND	48	0.23	0.40	0.021	0.044	17000
5	URBAN AND RURAL WET AND DRY MAINTENANCE	202	0.34	0.43	0.029	0.116	18000
6	URBAN AND RURAL WET AND DRY BMP	199	0.34	0.43	0.029	0.116	18000
7	URBAN FLOW CONTROL 60%	100	0.21	0.31	0.016	0.056	14000
8	URBAN OFFLINE PONDS AND FLOW CONTROL	34	0.16	0.29	0.011	0.023	13000
9	ALL (3-7) WITH STP REMOVAL	22	0.06	0.08	0.006	0.012	3000
	EXISTING	224	0.37	0.46	0.032	0.128	20000
	TARGET VALUE	200	0.10		0.005	0.025	100

DON RIVER REACH: MASSEY CREEK
PRECIPITATION CONDITIONS: 10 mm

CONCENTRATIONS (mg/l)

PARAMETER SS	TP	AMMONIA	COPPER	LEAD	FC
229	0.44	0.36	0.036	0.144	36000
229	0.44	0.36	0.036	0.144	36000
220	0.32	0.27	0.031	0.128	12000
54	0.29	0.31	0.024	0.056	34000
54	0.29	0.31	0.024	0.056	34000
207	0.41	0.34	0.033	0.132	35000
207	0.41	0.34	0.033	0.132	35000
98	0.27	0.21	0.018	0.069	30000
28	0.21	0.19	0.014	0.034	30000
15	0.07	0.08	0.009	0.014	5000
229	0.44	0.36	0.036	0.144	36000
200	0.10		0.005	0.025	100

DON RIVER REACH: LOWER DON RIVER
PRECIPITATION CONDITIONS: 20 mm

CONCENTRATIONS (mg/l)

	OPTION	PARAMETER SS	TP	AMMONIA	COPPER	LEAD	FC
1	STP UPGRADE	235	0.37	0.36	0.033	0.135	22000
2	STP REMOVAL	235	0.36	0.37	0.032	0.134	22000
3	CSO 90% REMOVAL	231	0.32	0.36	0.030	0.126	10000
4A	URBAN OFFLINE WET PONDS	62	0.23	0.35	0.021	0.047	20000
4B	URBAN/RURAL INLINE POND	51	0.23	0.35	0.021	0.047	20000
5	URBAN AND RURAL WET AND DRY MAINTENANCE	212	0.35	0.38	0.030	0.122	21000
6	URBAN AND RURAL WET AND DRY BMP	49	0.19	0.29	0.016	0.036	18000
7	URBAN FLOW CONTROL 30%	170	0.29	0.33	0.024	0.097	19000
8	URBAN OFFLINE PONDS AND FLOW CONTROL	43	0.13	0.18	0.015	0.032	7000
9	ALL (3-7) WITH STP REMOVAL	33	0.09	0.13	0.010	0.022	5000
	EXISTING	235	0.37	0.40	0.033	0.135	22000
	TARGET VALUE	200	0.10		0.005	0.025	100

NOTES: UNITS FOR FECAL COLIFORM ARE counts/100ml

DON RIVER REACH: MASSEY CREEK
PRECIPITATION CONDITIONS: 20 mm

CONCENTRATIONS (mg/l)

PARAMETER SS	TP	AMMONIA	COPPER	LEAD	FC
236	0.48	0.41	0.038	0.153	45000
236	0.48	0.41	0.038	0.153	45000
224	0.32	0.28	0.031	0.131	13000
58	0.33	0.35	0.026	0.064	43000
58	0.33	0.35	0.026	0.064	43000
214	0.45	0.38	0.035	0.141	44000
45	0.29	0.29	0.020	0.052	41000
169	0.39	0.33	0.029	0.115	43000
37	0.14	0.14	0.015	0.033	9000
26	0.10	0.14	0.011	0.024	8000
236	0.48	0.41	0.038	0.153	45000
200	0.10		0.005	0.025	100

6.0 SUMMARY

As part of the Strategy for Improvement of Don River Water Quality Study, a quantitative methodology was required to estimate the effectiveness of control options. The approach used in this component of the Don River study was the scenario approach. The scenario approach poses a variety of control options for evaluation and then consider their impact upon water quality.

The methodology used in this study consists of the following steps. Present day flows and concentrations of different contaminants from various sources were estimated to give loading to the river for existing conditions. The instream concentrations resulting from these loads were calculated and compared with measured concentrations. Next, the effect of different control measures on the magnitude of source flow or source concentrations were estimated. Then the impact of source control upon riverine concentrations were calculated.

Some of the key study results are listed below.

Precipitation Conditions

1. Not considering source concentrations, a significant degree of control could be attaned by controlling just dry and wet days with up to 5mm of rain which occur 87 percent of the time.

Discharge Volumes

1. The North Toronto STP accounts for 31 percent of the total daily dry weather flow volume.

2. The relative total seasonal volumes of discharge from highest to lowest are storm runoff at 71 percent, dry weather flow at 17 percent, North Toronto STP at 11 percent and CSO's at 1 percent.

3. Approximately 60 percent of the storm runoff volume occurs for events less than 10mm in size which represents 76 percent of the rain days.

Existing Source Loading

1. During dry weather conditions urban and rural discharges are the primary loading sources upstream of the STP. The primary source of the copper, lead and total phosphorus in the lower reach is the North Toronto STP.

2. Urban runoff is the predominant wet weather loading source for all parameters tested except for fecal coliform. In the lower reach and in particular in Massey Creek, the largest contribution of fecal coliform loading is from CSO's.

3. The larger fecal coliform loading from CSO's are due to the higher concentrations in CSO's. This is frequently two orders of magnitude higher than in storm water systems. Urban runoff sources dominate due to the relatively high volume of discharge associated with the source.

Existing Instream Concentrations

1. The concentrations are lowest in the upper Don River and increase downstream; this may be attributed to the fact that the upstream land uses are a mixture of rural and urban, while the lower catchments are fully developed; furthermore, the North Toronto STP and combined sewer overflows exist in the lower reach.

2. The concentrations, for a given condition, increase by a factor of 1 to 3-fold, from the upstream to middle reach and by an additional 1 to 10-fold from the mid to lower reach; Massey Creek, a heavily urbanized catchment with combined sewer overflows and industrial areas has concentrations of approximately 2 to 10-fold higher than the upper Don which is the least developed watershed.

3. The concentrations are lowest for dry weather conditions and increase by a factor of 1 to 30 for wet weather conditions.

4. Much of the river system may be stressful to aquatic life due to elevated levels of ammonia, copper and zinc, but the lower Don, during either dry or wet weather conditions, is the only stretch of river to have substantive levels of these and other (e.g., total residual chlorine) potentially toxic substances.

5. Pollutant loadings within the upper and middle reaches during dry weather conditions are primarily attributable to urban sources (infiltration/inflow into storm sewers, cross-connections between sanitary and storm sewers); in the lower reach, the urban sources and North Toronto STP are both significant pollutant sources.

6. The dominant source of pollutant loadings for wet weather events are the discharges from storm sewers; combined sewer overflow are a significant source for fecal coliforms and are only present in the lower reach; the North Toronto STP is a significant source of total phosphorus and ammonia in the lower Don.

The results were also used to compare instream concentrations to target values. For this study, target values are defined as concentrations which would, from a water quality perspective, support the specified beneficial uses indicated in the Summary Report. The findings show that, on average:

1. Suspended solids concentrations are well below the target value for dry weather conditions at all locations and are in the range of the target value for wet weather conditions; the target value reflects a fishery end use, not an aesthetic end use.

2. Total phosphorus concentrations during dry weather conditions are highest in the lower Don due to the STP (four times target value); the concentrations in the upstream reach are in the vicinity of the target value during dry weather conditions. For wet weather conditions, the concentrations exceed the target value by 2-fold in the upper reach and by 4-fold in the lower reach.

3. Ammonia concentrations are well below target values for all of the river system except downstream of the wastewater treatment plant. There, the concentrations approach, but are still below target values during wet and dry weather conditions.

4. Copper concentrations, during dry weather conditions, are also in the vicinity of the target value in the upstream reach; the concentrations in the lower Don increase by a factor of five. During wet weather, the exceedances vary from a factor of 3 to 6 for the upper and lower Don reaches, respectively.

5. Lead concentrations are generally below, or in the vicinity of the target value for dry weather conditions; for wet weather, the concentrations are about twice the level at the downstream reach as compared to values in the upstream reach; furthermore, they exceed the target value by 2 to 5-fold in the upper and lower reaches respectively.

6. Fecal coliform concentrations always exceed the target value by a considerable amount; the exceedances range from approximately 10-fold for dry weather (upper Don) to 250-fold for wet weather in the lower reach; Massey Creek wet weather conditions are higher than the Don River concentrations due to the combined sewer overflow loadings.

Control Option Effectiveness

The following remedial options were considered.

1. North Toronto STP upgrade,
2. North Toronto STP removal,
3. combined sewer overflow removal,
4. urban in--line or off-line ponds,
5. urban and rural wet and dry maintenance practices,
6. urban and rural wet and dry vegetated Best Management Practices,
7. flow reduction through redevelopment.
8. off line ponds and flow reduction through redevelopment,
9. Items 2 through 7 inclusive.

A considerable amount of effort was put into evaluating mitigative options which would reduce pollutant loads from the storm sewer systems, as the above analysis showed that this source produced a majority of the pollutant loadings.

Wet Weather Conditions

1. Urban wet ponds and flow reduction through re-development are the most effective options for reducting the concentrations of all parameters.

Collectively, implementing both options would reduce the concentrations during most rainfall events to values approaching the target value for suspended solids, total phosphorus, copper and lead.

2. Upgrading or removing the STP or eliminating combined sewer overflows are not as effective as the above options.

3. Fecal coliform target values could not be approaced using any of the above options.

Dry Weather Conditions

1. The construction of wet ponds or implementation of flow reduction techniques are the most effective options for reducing concentrations of most parameters in the upper and mid reaches. However, the effectiveness of these options to reduce instream concentrations during dry weather conditions has not been well documented. Furthermore, the simplified approach used in this study does not consider the secondary mechanisms (such as settling of fine particles during quiescent conditions) which would result in a reduction of concentrations. As such, the Tables (14-17) indicate that concentrations during dry weather conditions are insensitive to the control options.

2. The removal of the North Toronto STP is effective in reducing total phosphorus ammonia, copper and lead within the lower reach.

To achieve fecal coliform target values (100/100 mL) for either dry or wet weather conditions, additional control other than the above options is required. This would take the form of additional storage (residence time of longer than 4 days) or disinfection of pond overflows. Based upon the potential aquatic toxicity resulting from disinfection with chlorine (Supporting Document 2), disinfection with U-V light or ozonation is preferred. The latter two technologies are evolving and at this time are unproven within the confines of a stormwater management facility.

Based, in part, on the above findings and other qualitative assessment, a recommended strategy for improving the instream water quality was developed and is presented in the summary report. The strategy is meant to provide direction in an attempt to define

which beneficial water uses can be attained, which mitigating options are required, and what sequence should the options be constructed.

Ultimately, the principal uses which could be met include:

- improvement in water quality aesthetics;
- re-establishment of a warm water fishery;
- substantial reduction in pollutant loading to Lake Ontario; and
- significant improvement in swimming conditions in the river, and in beaches influenced by discharges from the Don River.

As was discussed previously, the feasibility of attaining non-contact or contact recreational activities with the Don River would be dependent upon additional options such as extended storage time or disinfection. The feasibility of these alternatives is uncertain at this time.

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APPENDIX 1

SUMMARY OF WATER QUALITY DATA FOR DON RIVER OUTFALLS AND TRIBUTARIES

SUPPORTING DOCUMENT 1

4139.5

There were four sources of water quality considered for use in calibrating the source model. These include:

i) a MOE wet weather event study (Saplamaeff, 1987) in 1986 at one location;

ii) the Enhanced Monitoring Program carried out by 1986 for both dry and wet weather periods;

iii) a MOE study (1986) covering both dry and wet weather periods at nine tributaries;

iv) the sub-catchment data at four locations (Mark Stirrup, pers. comm.) completed by MOE; and

v) the dry weather outfall study (by Canviro).

The wet weather event study (i) above, involved detailed water quality sampling for 12 events at the Todmorden/Bayview exit (Figure 1) during June to November 1986. The location is advantageous in that a Water Survey of Canada flow gauge is also located at this site.

The Enhanced Monitoring Program included sampling in the Lower Don River for both dry and wet weather events. In total, samples were taken for about 30 events over the period of 1982-1986.

The tributary sampling program carried out by MOE (iii) above, included three wet weather and three dry weather events. The nine locations are shown in Figure 1.

A summary of the data from studies (i), (iii), and (v) are now presented.

A data set used to check the calibration of the source quality model, the wet weather sampling undertaken by MOE River Systems in 1986 (Saplamaeff and Rutherford). Twelve events were sampled on the Main Don at Bayview. Generally, samples were collected on the rising limb, at the peak, and on the recession of the hydrograph. A summary of the concentration data according to size of storm is given in Table A1. The

TABLE A.1: SUMMARY OF DATA FROM TRIBUTARY MONITORING PROGRAM (Saplamaeff and Rutherford, 1987)

	Small Storms*			Medium Storms*			Large Storms		
	25th	Median or Geo Mean	75th	25th	Median or Geo Mean	75th	25th	Median or Geo Mean	75th
Fecal coliforms (#/100 mL)	13,000	49,000	96,000	15,000	45,000	96,000	18,000	49,000	118,000
E. Coli (#/100 mL)	12,000	29,000	62,000	9,400	25,000	65,000	13,000	36,000	87,000
Enterococcus (#/100 mL)	500	3,300	10,000	1,800	7,300	28,000	9,300	18,000	34,000
Copper (g/m^3)	.011	.023	.033	.010	.018	.032	.007	.023	.039
Lead (g/m^3)	?	.050	.095	.023	.050	.133	.058	.079	.133
Mercury (mg/m^3)	.020	.045	.080	.020	.045	.11	.050	.075	.115
Zinc (g/m^3)	.051	.103	.153	.059	.100	.213	.095	.130	.183
SS (g/m^3)	76	119	440	133	230	760	300	460	680
U-NH_3 (g/m^3)	.001	.003	.006	.001	.002	.005	.001	.003	.006

*Geo Mean used for bacterial parameters and ammonia. Median concentration reported for other parameters.

data shows an influence of storm size for parameters such as suspended solids, but generally not for the others. As the authors note, certain problems result from the partitioning process including:

i) the data are not uniformly partitioned, and
ii) the sample size within each range is small and varies between the ranges.

Hence, these data were used as a qualitative check upon the source model calibration.

A variety of studies have been undertaken to assess contaminant loads to the Don River from stormwater outfalls. This section presents a brief review of the calculations by Canviro (1986) and recent analyses of tributaries data by Rivers Systems professionals (1988).

The Canviro (1986) study surveyed 1421 outfalls during dry weather conditions. They were composed of the following sources

1184	storm sewer	(83 percent)
30	combined	(2.2 percent)
112	minor tributaries	(8 percent)
95	drainage ditches	(7 percent)
1,421		100 percent

One additional source sampled was the North Toronto STP.

During the dry weather period, the average low flow was 1,650 L/s, of which 1,250 L/s was derived from the outfalls and the remainder from the North Toronto STP.

The average flow weighted concentrations calculated by Canviro (1986) of selected pollutant parameters for all flowing outfalls including the North Don effluent are presented in Table A.2. North Toronto WPCP effluent quality data are presented separately. The average concentration in the outfalls derived from dry weather loadings divided by the total dry weather flow from the outfalls is given in column 4 of Table A.2.

TABLE A.2 SUMMARY OF OUTFALL AVERAGE FLOW WEIGHTED POLLUTANT CONCENTRATIONS (FROM CANVIRO, 1987)

Parameter	Average Outfall* Concentration	North Toronto WPCP	Loading Based Concentration From Outfalls**	Modified By-Law Limit
Fecal Coliform	44,300 org/100 mL	34 org/100 mL	140,000 org/100 mL	not specified
Fecal Streptococcus	4,900 org/100 mL	NA	-	NA
BOD	3.0 mg/L	14.7 mg/L	6.9 mg/L	15 mg/L
Total Phosphorus	0.4 mg/L	0.8 mg/L	2.7 mg/L	20 mg/L
Suspended Solids	7.2 mg/L	8.3 mg/L	25 mg/L	1 mg/L
TKN	0.4 mg/L	NA	1.2 mg/L	15 mg/L
Lead	0.02 mg/L	0.04 mg/L	.053 mg/L	20 mg/L
Zinc	0.01 mg/L	0.07 mg/L	.054 mg/L	1 mg/L
Copper	0.01 mg/L	0.04 mg/L	.058 mg/L	1 mg/L
Chromium	0.02 mg/L	L 0.01 mg/L	.036	1 mg/L
Iron	0.34 mg/L	0.46 mg/L	3.1 mg/L	1 mg/L
Phenolics	1.8 mg/L	NA	9 ug/L	20 ug/L

Note: * Includes North Toronto WPCP effluent except for fecal streptococcus, phenolics and TKN results.

** Calculated as loadings from outfalls divided by flow rate from outfalls (1,250 L/s)

There are significant differences between the "outfall average flow weighted concentration" calculated by Canviro (Column 2, Table A2) and the "loading based concentration" (column 4, Table A.2). The loading based concentrations are significantly higher. This results from a few outfalls dominating the estimates of loadings. For example, the following extremes are noted by CANVIRO (1986) for various parameters.

- Suspended solids - one outfall, RG944 in section 22 was responsible for 36 percent. Construction was observed upstream of this outfall.
- Total phosphorus - outfall NR1164, in Section 13, accounted for 79 percent of the loading. NR1164 is a minor Don River tributary, may be from adjacent industrial area. Crew noted odour of detergent and paint, petroleum residue and a brown soapy foam on the effluent surface.
- TKN (exclusive of WPCP) outfall RG944, in Section 22 accounted for 10 percent.
- Phenol - outfall EH162 accounted for 38 percent.
- Outfalls RG944 in Section 22 plus S13 368 in section 6 accounted for 19% of zinc.
- Sections 16, 2 and 22 accounted for 40% of the lead input.
- Outfall NR1254 in Section 13 accounted for 63% of the total copper load based upon one sample collection.
- Outfall ND 1479 in Section 2 accounted for 23% of the total load.
- Outfall RG944 accounted for 53% of the total laod of iron.

Part of these extremes result from highly contaminated sources which are currently undergoing remediation. Part of these extremes result from the limited number of samples. These potential problems have made it difficult to use these results as watershed scale loadings during dry weather flows with complete assurance.

It led to subsequent studies in 1986 which attempted to define loadings based upon monitoring of small tributaries during dry conditions. The sampling programs are quite helpful and imaginative. The following data were analysed recently by professionals with MOE (C. Kennedy, personal communication and file data).

Don R. Trib. Stn.

Stn.	Dry	Wet	Description of Station
4	0	0	Massey Creek at Mouth
5	0	0	Massey Creek upstream of CSO sources (metal plating upstream)
8	0	0	Wilket Creek (potential area for pesticides/herbicides)
9	0	0	Barnes Creek (feeds in Sunnybrooke Creek - residential)
10A	0	0	Darlington Park (residential area near North York Hospital)
10B	0	0	Small Creek near Bayview (residential)
12	0	0	German Mills Creek at mouth
13	0	0	Small Creek feeding into German Mills (light industrial, commercial; just upstream of Steeles
15A	0	0	West Don north of Steeles (near Marshalling Yard)

The data base gathered varies. The following number of events have been summarized at the different stations.

Station	No. of Events
4	2
5	1
8	1
10A	2
12	2

The loadings from analyses of the wet weather events, and dry weather samples (3 samples; 3 flow estimates) at each location are given in Tables A3 to A10. There is a considerable range of loadings. For example, for several stations, loadings during the wet weather events are of the same order of magnitude or smaller than loadings for the dry weather periods. The loadings from the CANVIRO dry weather study are similar to the "measured" tributary loadings for some parameters, but often one-four orders of magnitude larger.

There are several probable reasons for the discrepancies including considerable uncertainty in the duration of the flow estimates, uncertainty and/or variability in the concentration estimates, and differences in the time frame of the data base. In the case of the event data, the NURP data show that one or two events are insufficient to characterize the SMC (site median concentration) for any catchment. Six to eight events at least are required to define the SMC. Three events may provide some degree of representativeness to the assessment. If the range of EMC's typical of NURP data are observed at a station such as 10A or 10B, two events potentially give some useful information.

Further work is in order to provide a common base for assessing the inter-relationship between the CANVIRO data and the tributaries data, both from the tributaries described above and the several events observed on the Main Don (Table A1).

The common basis would assess:

- o the representativity of the flow estimate; and
- o the representativity of the concentration measurement.

It might require integrating quality data from a variety of outfalls or similar characteristics and from tributaries of similar characteristics to provide estimates for concentration which have more confidence associated with them for the different points being considered. It might require an outlier analysis. Outfalls which are clearly contaminated would need to be separated from outfalls which are less contaminated. Subsequent outfall monitoring would also need to be included in the study.

For purposes of this study, these data were used as a guide to selecting concentrations for the water quality loadings model for the watershed. The calibration procedure outlined in the main body was the main tool used in final selection of source concentrations.

TABLE A.3: TOTAL LOAD FOR STATION 4 MASSEY CREEK

	Wet Event 1	Wet Event 2	Dry Weather Load	Canviro Dry Weather Load
Fe	340	2,100	850	2,600
Cr	2.7	6.4	17	190
Cu	3.9	10	8	50
Pb	9.8	7.4	86	430
Zn	18	52	46	190
SS	22,000	46,000	2,600,000	48,000
TP	37	90	60	720
TKN	160	260	1,100	5,900
FC	7E9	12E9	0.006E9	0.64E9

TABLE A.4: TOTAL LOAD FOR STATION 5 MASSEY CREEK

	Wet Event 1	Wet Event 2	Dry Weather Load	Canviro* Dry Weather Load
Fe	37	-	20	14,000
Cr	0.3	-	0.8	460
Cu	0.3	-	0.3	300
Pb	1.3	-	1.3	500
Zn	2.3	-	5	1,300
SS	2,000	-	54,000	138,000
TP	2.9	-	4	18,000
TKN	10	-	34	8,400
FC	1E8	-	0.004E8	2E8

*Outfall loading more than order of magnitude greater than measured dry weather load.

TABLE A.5: TOTAL LOAD FOR STATION 8: WILKET CREEK

	Wet Event 1	Dry Weather Load	Canviro Dry Weather Load
Fe	9.2	88	430
Cr	.02	2	60
Cu	.03	1	29
Pb	0.1	22	140
Zn	0.2	6	140
SS	350	300,000	9,000
TP	0.4	24	500
TKN	1.3	200	4,900
FC	2E7	0.01E7	0.3E7

TABLE A.6: TOTAL LOAD FOR STATION 9: SUNNYBROOK TRIBUTARY

	Dry Weather Load	Canviro Dry Weather Load
Fe	50	36,000
Cr	2	200
Cu	1	100
Pb	11	370
Zn	4	240
SS	390,000	690,000
TP	7	2,500
TKN	130	4,600
FC	0.3E6	4E6

TABLE A.7: TOTAL LOAD FOR STATION 10A: BUCHAN CREEK

	Wet Event 1	Wet Event 2	Dry Weather Load	Canviro Dry Weather Load
Fe	23	0.5	60	260
Cr	0.2	0.006	2	2
Cu	0.3	0.02	0.7	2
Pb	1.0	0.03	7	5
Zn	2	0.1	10	5
SS	1,300	-	230,000	5,100
TP	3.3	0.1	16	28
TKN	12	1	130	500
FC	0.6E9	0.03E9	1E6	-

TABLE A.8: TOTAL LOAD FOR STATION 10B

	Dry Weather Load	Canviro Dry Weather Load
Fe	42	190
Cr	2	80
Cu	1	10
Pb	6	17
Zn	3	30
SS	160,000	7,000
TP	4	90
TKN	80	600
FC	0.1E6	1E6

TABLE A.9: TOTAL LOAD FOR STATION 12: GERMAN MILLS CREEK

	Wet Event 1	Wet Event 2	Dry Weather Load	Canviro Dry Weather Load
Fe	8.1	55	800	11,000
Cr	0.06	0.2	12	140
Cu	0.05	0.2	14	140
Pb	0.3	1.0	70	590
Zn	0.3	1.6	23	500
SS	-	2,500	1,400,000	140,000
TP	0.8	2.1	70	1,200
TKN	6	7	700	7
FC	8E7	4E7	0.1E7	E7

TABLE A.10: TOTAL LOAD FOR STATION 13: GERMAN MILLS CREEK

	Dry Weather Load	Canviro Dry Weather Load
Fe	40	8
Cr	0.8	0.8
Cu	0.5	0.4
Pb	5	0.2
Zn	3	0.8
SS	110,000	500
TP	5	0.8
TKN	110	10
FC	0.7E6	0.01E6